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EDITORIAL.

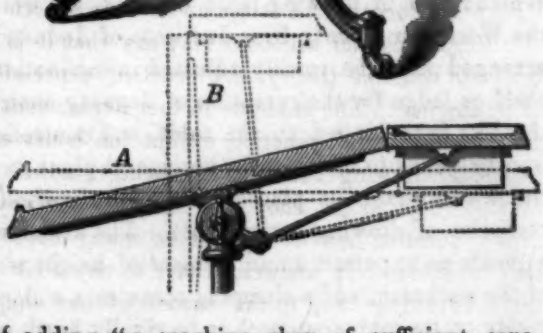
ITEMS AND NOVELTIES.

The Worcester County Free Institute of Industrial Science.—*With Remarks on the Technical Education of Mechanics.*—By COLEMAN SELLERS, President of the Franklin Institute.—It is my desire to call your attention this evening to an ingenious and convenient form of drawing-table or desk, the work of the students of the Worcester County Free Institute of Industrial Science. It is so arranged as to be readily adjusted in inclination of surface, while a shelf or ledge for the reception of drawing instruments, inkstand, or the like is so hinged to the table, and controlled by a bar or rod of iron below, as to maintain its horizontal plane in whatever inclination the drawing-table is placed. Beneath the shelf are drawers for the reception of drawing instruments. The attachment to the tripod is so made as to permit an adjustment of height to suit the convenience of the workman, and a clamping-screw in a collar permits the table to rotate on its centre support or be rigidly fixed in any required position. Thus you see it can be used as a high or low desk and a high or low table. It can also be so placed as to serve the purpose of a painter's easel. In the library it is a most useful piece of furniture.

As an easel it may be used to display a picture or engravings. As a table it is a convenient support for the microscope, and its ready elevation makes it useful to carry a spectroscope. These are the uses to which I expect to apply this table. Thus you see it is one of those very convenient pieces of furniture that when once tried becomes an indispensable luxury. It fills a want long felt, and its cheapness brings it within easy reach of all. Apart from its mechanical excellence, however, I feel a deeper interest in its makers. I have said it is the work of students in an industrial school. A few words about this school, its aim and method of working, may not be amiss in an Institute whose whole effort has been to promote the mechanic arts.

Fig 1

Fig. 2



This school was founded by one John Boynton, in the year 1865. To his gift of one hundred thousand dollars, other liberal citizens added various sums, until a school was established on a firm basis. In the year 1866, the Hon. Ichabod Washburn conceived the idea of adding "a machine shop of sufficient capacity to employ twenty or more apprentices, with a suitable number of practical teachers and workmen in the shop to instruct such apprentices, and provided with all necessary steam-power, engines, tools,

apparatus and machinery, of the most improved models and styles in use, to carry on the business of such machine shop in all its parts as a practical working establishment," his wish being that the apprentices entered should have as good a chance to become proficient workmen as if brought up in any of the best workshops, with the addition of some mental training. In the deed of gift Mr. Washburn made the wise provision that in event of any insurmountable difficulties arising in carrying out the plans, the money might be merged into the general fund of the Institute. So far as I have been able to learn, the design of the school is, in its scope and purpose, much like the technical schools of Europe, giving prominence to the practical element. It is not my intention this evening to review the entire course of practice and studies, but rather to draw your attention to what I have learned in regard to the management of these apprentices. The managers of the school, knowing the interest I have taken in the subject of the education of mechanics, have given me much information regarding the theory of its operation.

It seems that a five months trial is deemed sufficient to demonstrate the fitness of any student to pursue the mechanical career; if he shows too little mechanical talent, his true bent may be discovered, and he is then transferred to such department as may best fit him for active life; so that the non-mechanics become weeded out, and those who continue are the more careful. The boys are advanced as rapidly as possible, and are freed from drudgery as soon as practicable. They are taught habits of industry, and made to feel the dignity of labor. Free-hand drawing is an imperative necessity. Mr. Chas. H. Morgan, in a letter under date March 10th, 1873, says:

"Regarding our school, I may say that it is successful in its attempt to combine theory and practice, especially in the department of mechanics. The students in this department are required to have five months (solid) practice, except ten hours each week devoted to free-hand drawing before commencing studies. We have at present fifty-six boys in the shop and only six journeymen. You will certainly question how we manage so many boys, and we found it no easy problem. In answer, I have to say that we have found it for their advantage and to the success of our shop, to employ them at wood work for the first year, in making small articles that require but little material; the time is well spent, and we gauge their capacity at the least expensive work, and we find that boys make quite as much advancement in working iron during the term for having had

this practice in the wood shop. The drawing table is the work of students; they also make models for drawing. The senior class work on the speed and engine lathes." The machine tools turned out by the students are said to be well made. The boys entering the shop find workmen employed producing work for sale; they are employed at such parts as they can do to the best advantage, and their work is sold, but they receive no wages. Mr. Washburn did not believe such a shop could be made self-supporting, and he provided for this contingency by the interest of a fund of $50,000.

"With all these advantages the work done by the apprentices is hardly an adequate compensation for the expense involved in instruction." I understand that the object of the superintendent is to maintain the highest standard of workmanship practicable, and as the aim is to teach, not to make money, it becomes possible, by judicious management, to employ usefully nine apprentices to one journeyman.

The business of the shop amounts to about ten thousand dollars annually. The profits with the income of the endowment fund have so far just equalled the expense of operating it. It is claimed that the element of personal responsibility enters with every student's work, and all mere turning of material from one form into another for the sake of observing the process, is avoided. Two classes have been carried through the three years' course, and are successful as journeymen and as draftsmen in first-class machine shops. Students intending to take the course of mechanical engineering must begin their apprentice course five months sooner than any other class of students, and these five months are sufficient to enable the superintendent to determine the fitness of the student for the profession, and then, in case they have no aptitude for mechanics, they can enter the full term as civil engineers, or in architecture, drawing and design; in chemistry, or in English, French and German, certain studies being common to all these departments, as it is the aim of the institution to give as complete a general education as possible, and to point out the true relations of theory and practice. The course of study covers three years—senior, middle and junior.

There seems to me much that is good in this experiment in American education. No three years in school or in workshop can turn out proficient mechanical engineers. It can only start them in the right road to reach the goal. But any system that will give us educated mechanics accomplishes something in the right direction. It is from our stock of educated mechanics that we must hope to draw our na-

tion's future prosperity. Skilled workmen are in demand, but if we depended upon our skilled laborers alone, we would soon fall behindhand. Well directed ingenuity, however, takes the place of skill, enabling unskilled workmen to produce new and better work than skill, unaided by machinery. The scythe and cradle drove the sickle out of the harvest field; but where are the mowers of this vast continent? happily, a boy on a mowing machine can do more and better work than many skilled reapers and mowers.

The skilled mechanic of by-gone days could do marvels with his chisel and file, but the planing machine and scraper have already almost numbered his trade with the lost arts. The skilled workman of to-day may in a few years find no use for his handicraft; but if he to his skill has added a well-stored mind, he becomes invaluable; for it is from the progressve mechanics that we draw our stock of foremen and leaders. Good judgment, ingenuity, knowledge of what has been done by others, with moderate skill, is what is needed; and when to these we add general mental culture, the happy possessor is more sure of success in life than any others who have not been born with silver spoons in their mouths. For in these days of iron and of railroads, the educated mechanic is in demand.

Philadelphia stands to-day the greatest manufacturing city of this continent. In its 8339 establishments, well nigh $200,000,000 worth of machinery is adding its products to the commerce of the country, and yet among all this hum of busy industry, with a full knowledge that it is far better that our sons shall have good trades to fall back on, after their school-days are past, the problem of what is best for their future is pressing on each one of us daily. It is impossible for all the boys who desire to enter the workshops in this city to find employment. There is a limit to the amount of apprentice labor fixed by possibility of profit to the employers. Hence schools such as this at Worcester, if successful, must be of great use. And any system of education that to mental culture adds manual skill and impresses the student with the fact that there is dignity in manual labor, and that implants in him habits of industry and frugality, is to be encouraged. Feeling the importance of the subject, I have been induced to make this convenient little table an excuse for barely touching on a subject of so much interest to every parent or guardian. Having thought much on this subject, I hope at no very distant day to be permitted to present to the Institute a more carefully prepared paper on the technical education of the American mechanic.

A Huge Band Saw.—The Journal noticed, some time ago, that a band saw of unprecedently large proportions was in course of building, for Mr. J. J. Van Pelt, of New York, at the establishment of Messrs. Richards, London & Kelly, of Philada.

The machine was delivered some time ago, and has been for some months in successful operation, at the mills of the gentleman above named.

The dimensions of the machine are as follows: Saw, 55 feet long, 4½ to 6 inches wide and of 16 gage; manufactured by Perin & Co., Paris.

The pulleys are 75 inches in diameter, including hubs of wrought iron, and are mounted centrally on the main column, so as to equalize the strain of the saw, and prevent its springing, and to economize its weight.

They are covered with a lagging of pine, over which is glued an envelope of heavy harness leather.

The bearings for the wheel shafts are four inches in diameter, and twelve inches long, and are made of an alloy of 6 parts of copper and one of tin. The tension is from one to four tons, and necessarily calls for the greatest rigidity in the framing to prevent the guides from being thrown out of position by the varying tension of the blades.

The kerf of the saw is said to be less than that of a circular saw. Speed is 4,500 feet per minute. Pine timber can be cut at the rate of sixty feet, and oak and yellow pine at the rate of thirty feet per minute, the logs being from one inch to five feet in thickness.

It is said that the saw will follow the curvature of long timber, such as is used in ship building, and is cut with the grain. This property not only effects considerable economy in the timber over the circular saw, but also adds to the value of the work.

The experiment is declared on all sides to have proven a complete success; and will doubtless lead to others no less novel.*

The Steam Jacket.—Before the Scientific and Mechanical Society of Manchester, England, the subject of the steam jacket, its advantages and disadvantages and economy were discussed, and some interesting differences of opinion manifested. Wm. A. Hildebrandt maintained the assertion that the use of the steam jacket was opposed to economy. He stated his position as follows: Its advantages are,

* Sci. Amer., March, 1873.

1st, that it slightly increases capacity of the cylinder, by keeping the steam within dry; 2d, it affords greater immunity from breakdowns, since it prevents the accumulation of condensed water in the cylinder. Its disadvantages were thus stated: 1. Waste of fuel. 2d. Increased labor in its attendance. 3d. Increased outlay of capital, amounting to about 20 per cent. From this presentation, Mr. H. pronounces the judgment that the steam jacket must be declared to be not economical. In the discussion which the paper elicited, several prominent engineers expressed themselves strongly in favor of the jacket; others as strongly against it. One member, for example, states that from careful observations for several months, upon an engine with a steady load, he found that by discontinuing the use of the steam jacket a saving of 10 per cent. of fuel was effected.

Increase of Iron Works in 1872.—The following tabulation from a contemporary will serve to give a tolerably clear estimate of the progress of the iron industry of the country.

STATE.	FURNACES.		ROLLING MILLS.		TOTAL.
	Built.	Projected.	Built.	Projected.	New Works.
Pennsylvania,	48	11	15	5	79
Ohio,	13	6	7	4	30
W. Virginia,	1		1		2
Indiana,	4	1	2	1	8
Illinois,	3		4		7
Missouri,	6	2	1		9
Tennessee,	5	2	1		8
Wisconsin,	8				8
Michigan,	6	5	1		12
Massachusetts,	1		1		2
New York,	4	1	2		7
Vermont,			1		1
Connecticut,	1				2
New Jersey,	1				1
Georgia,	2	7			9
Alabama,	2			1	3
North Carolina,	1	4			5
Total,	107	39	36	12	194

Iron Production.—In connection with the foregoing statement of the progress of the iron industry of the country, the following abstract from the report of the secretary of the Pig Iron Manufactur-

ers' Association may be of interest. From this document we glean the information that the make of iron during the year 1872 amounted to 2,388,250 tons; divided as follows:—Anthracite, 1,197,010 tons; raw bituminous and coke, 712,500 tons, and charcoal, 478,500 tons.

From an inspection of the table above given, it appears that the increase in the number of rolling mills has kept pace with the number of blast furnaces.

There was consumed in the country during the year, 4,054,618 tons of iron, including 400,000 tons of American scrap. One-tenth of the total consumption was American scrap, three-tenths imported iron, and six-tenths American pig. The consumption was divided as follows:—In casting, 1,103,000 tons; in railroad supplies, 2,478,500 tons, and in miscellaneous wrought iron products, 730,000 tons.

The ore production for the past year was very largely in excess of that of previous years, being 6,400,000 tons.

The report further states that five Bessemer works were in operation (four new ones being projected at date of report), consuming 125,361 tons of pig metal, and fixes the production of Bessemer rails for the year at 90,000 tons.

Hoosac Tunnel.—The progress of this work, up to the 1st of March, 1873, is stated to be as follows:

Extension of headings during the month of February, 277 feet.

Total worked accomplished: from the east end, westward, 13,480 feet; from the west end, eastward, 8,966 feet; total, 22,746 feet. Leaving still to be opened, 2,555 feet, or somewhat less than half a mile.

An Improved Safety Lamp.—An invention ascribed to Mr. William Yates, claiming to be a great improvement upon the Davy Safety Lamp, is thus described:* The wire gauze is removed from that part of the lamp surrounding the flame, and its place is supplied with a bull's-eye glass in front and a polished silver surface behind; thus securing a brilliant, cheerful light, and removing the temptation, which with the old lamp is very strong at times, to remove the gauze to obtain sufficient light. The light thus obtained is stated to be twenty times greater than with the old Davy; and again, the flame is placed so low that it cannot be made to approach the gauze by the breath or by tilting the apparatus. The lower portion of the lamp,

* Engineer, Feb., 1873.

containing the oil reservoir and the wick, which is screwed to the part which consists of the gauze funnel, the bull's-eye and the reflector, has a spring-bolt attached to it which catches each time the screw is turned, and finally locks together the two parts of the lamp. The bolt is easily removed by another screw, but this cannot be done without, at the same time, withdrawing the wick and extinguishing the flame, thus making it impossible to obtain a light by opening the lamp.

It seems, therefore, that this new improvement remedies the defects of the old lamp, to which many of the accidents occurring in the mines are attributed.

Silk Manufacture.—The statistics of this industry in the United States indicate a most surprising and gratifying increase. Ten years ago it was in its infancy, and purely an experiment; now it has attained to vast proportions, and bids fair to speedily become one of the most prominent manufactures of the country.

The recently published annual report of the Silk Manufacturer's Association contains the statement that $30,000,000 are invested in this industry in the country, and sixteen thousand operatives are employed, whose wages reach $8,000,000, and the value of whose production is estimated at between 30 and $40,000,000.

A New Solvent for Iodine, BY DR. I. WALZ.—I find that glacial acetic acid is an excellent solvent of iodine, certainly not inferior to alcohol. On heating acetic acid with excess of iodine to boiling, and then allowing to cool slowly, beautiful, large, slender crystals of iodine will form (sometimes half an inch long.) The crystals formed from supersaturated alcohol solution of iodine are short, of arrow-head shape, and by no means so abundant, for glacial acetic acid takes up far more iodine hot than cold. I hope you will make this easily executed experiment, and you will then see the finest iodine crystals yet produced.

If saturated alcoholic and glacial acetic solutions of iodine are mixed in equal proportions, and allowed to stand, *acetic ether* is formed. The presence of a little MnO_2 and a drop of SO_4H_2 seems to promote the formation, but is quite unnecessary.

Elongation by Magnetization.—Prof. Mayer has announced some instructive conclusions from a series of experiments upon magnetism. These experiments were made with a view to determine any change of dimensions suffered by bars of steel or iron by magnetiza-

tion. The apparatus employed for this purpose was extremely delicate, and capable of measuring a variation in length of one two hundred thousandths of an inch. By means of this apparatus he determined that bars of iron suffered an elongation when a current of electricity was passed through them; when the current was interrupted the bars shortened somewhat, but never quite regained their original length. With annealed steel bars the results were the same; but with tempered steel they were quite different. Upon passing a current around these they contracted, and on interrupting the current they contracted still further.

A New Colorimeter.—A new instrument of this kind has been suggested. It consists of two pieces of glass, touching at one end, and held apart at the other by a strip of platinum.

Upon one of the plates a series of fine lines is engraved; and the intensity of any two colors is determined by comparison of the depth of liquid which it is necessary to add until the lines before referred to become invisible.

The Oxyhydrogen Light.—The conclusions reached by M. Le Blanc, who has given the new method of illumination a thorough examination, are that in point of economy it affords but little gain over the ordinary method of gas lighting.

The method of illumination cannot well be carried into effect without the attachment of carburizers and regulators at the foot of each lamp-post. The friends of the invention in France are said to acknowledge that the plan is not practically adapted for street illumination.

Correction.—In the March number of the Journal, in the description of an improved testing machine, on page 146, there occurs the statement that, owing to a peculiar arrangement of the bearings and fulcrums of the machine there was *no* friction. The error was, at the time of printing, overlooked, in making a hasty abstract of a lengthy description which had been offered for publication. As the statement, if uncorrected, might lead to the suspicion that the Editor was a convert to the doctrine of perpetual motion, this opportunity is taken to call attention to the misstatement.

Obituary.—There was none greater, in the science of engineering, in the broadest sense, than William John Macquorn Rankine, late Professor at the Glasgow University, recently deceased in that

city; and the following resolutions, passed at a meeting of the Faculty of the Stevens Institute, testify to the esteem, we might almost say veneration, in which Professor Rankine was held by his scientific *confreres* throughout the world.

At a special meeting of the Faculty of the Stevens Institute of Technology, held Wednesday, January 15, 1873, the following resolutions were moved by Prof. Thurston and unanimously adopted:

Resolved, That we have learned with profound regret the death of Professor William John Macquorn Rankine, of the University of Glasgow, Scotland.

Resolved, That in his death we feel that we have lost a most eminent member of the Engineering Profession, a distinguished brother in science, a rarely-gifted scholar, and one who, in a degree seldom equalled, has aided the great cause of the application, in technical and general education, of scientific knowledge.

Resolved, That we find, in the vast amount of valuable work accomplished by the deceased, cause of thankfulness to Him who doeth all things well for the preservation until now of so fruitful a life.

Resolved, That copies of these resolutions be forwarded through the United States Consul at Glasgow, to the Council of the University of Glasgow, and to the family of the deceased.

HENRY MORTON, President.

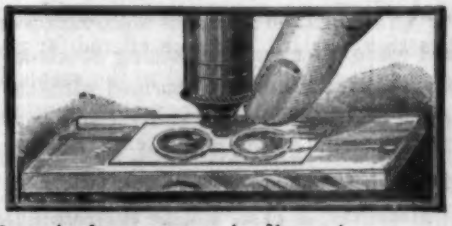
C. F. Kroeh, Secretary.

OPTICAL SECTION.

A New Slide for the Microscope.—At a recent meeting of the Optical section there was described and exhibited in operation a new adjunct to the microscope, designed by Mr. D. S. Holman, a member of the Section, whose life slide recently attracted so much attention and comment.

The new device may be called a current cell, and is designed to afford the microscopist the opportunity of observing and studying the constitution of the blood and other organic fluids with much greater ease and precision than it has heretofore been found possible to attain.

The accompanying illustration will serve to make the description of its construction and operation manifest:



The slide consists of a plain piece of plate glass of considerable thickness, and three inches or more in dimensions.

This is furnished at equal distances from its centre with two well

polished shallow cavities of circular form, which are connected with each other by two capillary channels. These channels are likewise polished, and to permit of a greater field in focussing for their contents, the groove of the tube is made triangular in section, with one side forming a right angle with the surface of the slide, and the other forming with it a very large angle.

The arrangement of the cell, or moist chamber, is as follows :

In order that the current shall be most sensitive, the slide should first be brought nearly to the temperature of the body by holding it for a few minutes in the hand. A small quantity of the liquid to be examined (blood, for example), is then to be placed in each cell, and a thin cover glass placed upon them. If held down for a moment with the hands, the air within the cavities will become slightly rarified, and the cover glass so firmly held in place by atmospheric pressure as to require no artificial attachment.

Upon removal of the fingers, it will be found that the centre of the cavities is occupied with a bubble of air, while a thin annulus about the circumference, as well as the connecting capillary tubes, are occupied by the fluid.

The slide is now ready for inspection. If placed beneath the microscope, and the instrument is focussed upon the connecting channel, a number of corpuscles, red and white, will be observed, but quite quiescent. Let the finger be now approached to the neighborhood of either cell, when at once a current, more or less rapid, according to its proximity, commences to flow beneath the object glass ; remove the finger, and the direction of the current is reversed.

The current is caused by the expansion of the air bubble in the cell, in consequence of the heat radiated from the finger ; and its rapidity may be controlled to a nicety by regulating the proximity of the finger. So sensitive is the apparatus, that even with the highest powers, a corpuscle, granule or cell in the field of view, may be leisurely turned over and over in any desirable position, thus affording an unequalled means of observation and study to the microscopist ; and while the eye is examining at leisure the behavior of the objects beneath it, the mind is charmed with the simplicity of the means by which these motions are controlled.

In the cell here described, no foreign liquid is added to the material under examination.

Moreover, if each cell be entirely filled, but with liquids of different densities, the cell holding the denser liquid being placed slightly

uppermost upon the rotating stage of the microscope, the action of gravity will cause two currents to flow in opposite directions through the communicating channels, and in this way the phenomena of transfusion, crystallization, etc., may be observed for a considerable length of time, which otherwise are brought to sight only with difficuly.

At the conclusion of the description, the ingenious and useful device was highly praised by those members present, who were best able to appreciate its value, and its exhibition beneath the microscope was the occasion of much interest.

Bibliographical Notices.

On the Strength of Bridges and Roofs. By SAMUEL H. SHREVE, C. E. New York: D. Van Nostrand, 1873.

There has probably been no one branch of technical engineering literature upon which so many pamphlets, essays and treatises have been written, as upon the subject of bridge and roof construction; and it might be made an interesting subject of speculation to inquire the reason for such an expenditure of mental force in that direction. To add to the theoretical division of the subject, little or no room is left for the original investigator, always excepting the discussion of swing bridges and the rigid and braced arch, concerning which we have little that the practising engineer can readily understand or apply. We may divide the various modes of treating the subject most conveniently into the "Arithmetical," the "Analytical," and the "Algebraic," which, while strictly an incorrect division (as any treatment must be analytical), still it answers the purpose for the present, if we understand the intermediate method as the one employing the calculus and "higher" mathematics.

To the last class Mr. Shreve's book belongs, and throughout he has kept up a harmony of discussion and symbols that is in strong contrast with the mixed methods employed by most writers on such topics. While, of course, there is nothing new in the abstract in any of Mr. Shreve's discussions, there is a great deal in the mode of applying well recognized principles, as well as in the natural progression from simple to complicated forms of trussing. He has adopted the method of sections, a process of great flexibility, but as developed by all other authors, it involves an amount of time for its application not usually at the disposal of the engineer. The method of sections requires no "refined" mathematical knowledge, but it does require familiarity

with the simpler algebraic processes, as well as a knowledge of the elementary laws of mechanics as embodied in the principle of the lever and the resolution of forces. It has a further value in that it is perfectly general for all trusses of whatsoever form, such forms being always special cases under the general law. For this reason, it is probably the *best* method of bringing before the student a comprehensive theoretical knowledge of bridge construction, which, of course, must be mastered before he can make a further step forward, and learn to put his "strain diagrams" into a practical shape. For office practice, no method can ever supersede the arithmetical method, as first suggested by Mr. Whipple twenty-six years ago—that is for *parallel beam trusses*, a method of analysis now used by nearly all actively employed engineers, perhaps with some modification, but essentially the same now as then.

It is useless to expect other than "student engineers" to revel in the calculus and such analytical methods, and it is that which has marred more than one of our intended text books. Mr. Trautwine, in the preface to his "Hand Book," expressed a sweeping contempt for "mathematical rubbish," and as he probably meant it, he was quite correct. "Linea brevissima recta est" must be, of necessity, the engineer's motto, life being too short for "elegant refinements" after a man has passed his college days; only he must be careful to be sure that his straight line is in the right direction, or he may find himself sadly astray. There are some higher forms of trussing, in which it is difficult to avoid algebraic analysis of some sort, forms which arithmetical methods fail to reach—such as bow-string girders, lenticular and curved chords. The resolution and composition of forces so often applied to such forms are fearfully tedious, not to mention the errors multiplying through so much scale transferring. It is just here that we must beg aid from the "mathematical rubbish," and there probably can be nothing simpler than the method of sections applied to such forms. It will always meet the case, and, as Mr. Shreve has shown us, in a way that appears to be the essence of simplicity. Under a variable load, the difficulties by any other method intensifies to a brain-splitting degree, and while it is bad enough even by the method of sections, it is probably the only one that can be employed successfully by the average educated engineer. All writers, so far as the writer is aware, flounder on the bow-string variably loaded, if they avoid the method of sections. Who could rise from a perusal of Rankine, and say that he understood his discussion of it?

Mr. Trautwine does not touch it, but simply quotes Rankine, frankly disavowing any knowledge of what Rankine meant. Stoney, whose work, taken all in all, is the best treatise in the language on the subject on which it treats, and which no constructing engineer can afford to be without, descends from his usually simple manner of discussion, and gives a special case, worked out by the never ending and error-multiplying resolutions of forces. Humber deals in glittering generalities, and leaves the enquiring student profoundly impressed with the higher mysteries of the profession. Ritter's "Bridge and Roof Construction" (most *wretchedly* translated, scissored and printed by Diedrich in his(?) "Theory of Strains"), is in the main an arithmetical application of the method of sections, covering all possible forms of trusses, arches, domes, etc., and with a degree of thoroughness that only a German has patience to develop; but, being *arithmetical*, the processes are long and tedious, besides which the manner of taking moments allows of error. For a bow-string, for example, he passes a plane through each panel, so as to cut but three members, the intersection of any two prolonged being used for the centre of moments for the web members, the centres of moments in the web chords being, of course, taken in the chords themselves.

Coming, now, to Mr. Shreve's book, we find the radical modification of the usual manner of treating the method of sections consists in his deriving the web strains from the horizontal components of the chords, and by so doing he has been enabled to so simplify his formula as to make them readily available. It is the web strains that have always given the trouble, the chord strains being readily enough computed.

The arrangement of the book is admirable, the student being led gradually from the simpler to the more complex forms, the same formula following him throughout, simply being modified as the several cases vary. No case is treated as a distinct topic, isolated in itself, but merely part of the whole, in which its great value to the student in a great measure consists. *Every* form of truss treated is followed by an example worked out in detail, showing the application of the formula an excellent aid to a proper appreciation of the method of investigation. There are a few engineers still living who adhere to the idea that the centre brace is unaffected by the dead load of a structure, and therefore is required to be of full section, and extended throughout the whole length of the truss. To such the discussion of Mr. Shreve on the subject will be of value as being clear and con-

vincing, in which nothing is *assumed*, but deduced purely from the few simple mechanical axioms that lie at the bottom of all construction. This is a noteworthy peculiarity pervading the whole book, and not the least among its merits. Mr. Shreve has been happy in his explanatory remarks, indulging in no verbosity, but expressing tersely and unmistakably just what he means, leaving nothing to be inferred. In a little over 300 pages he explains and analyzes under one system almost all forms of independent trusses, giving worked-out examples of each, and in many cases takes his examples from actual structures.

Some ten pages are devoted at the end of the book to the subject of columns, which not being subject to theoretical analysis, is evidently out of place in a book of this character. Besides this, the information given is meagre, and amounts simply to quoting Hodgkinson's formulæ for cast and wrought iron columns, not touching Gordon's rule at all—the rule by which most engineers are governed, as being convenient to apply and perfectly safe.

The rules for the strength of columns are purely empirical, and therefore their discussion belongs more properly to the "strength of materials," which Mr. Shreve does not touch at all.

Apart from this unwise addition to the book, Mr. Shreve has produced a work that must always take high rank as a text book, and while not exactly fulfilling the requirements of an office hand-book, no bridge engineer should be without it as a valuable work of reference and one that will very frequently assist him out of difficulties.

As before remarked, for trusses with curved chords, bowstrings, etc., it appears to be clearer than any book heretofore issued, so far as examined by the writer, and it is hard to imagine anything more simple than the manner in which Mr. Shreve adapts the "Method of Sections" to such forms. The author promises a second volume, extending the same principle and methods to the consideration of continuous girders, swing bridges, cantilever trusses, braced arches, etc., and it is to be hoped that the profession will not be kept long waiting for it. The publisher deserves a good word for the handsome manner in which the work is produced, in the well arranged type, thick toned paper and substantial binding, although a little more care in the press work would still further have enhanced its appearance.

ALFRED P. BOLLER.

New York, March 7th, 1873.

Civil and Mechanical Engineering.

BESSEMER MACHINERY.

A Lecture delivered before the Students of the Stevens Institute of Technology by ALEX. L. HOLLEY, C. E.

(Continued from Vol. LXIV, page 399.)

The Bessemer blowing cylinder valve, at first universally and still somewhat used, is shown by Fig. 10. It is simply a rubber band, encircling the end of the cylinder, and opening and closing the air-holes, over which it lies, by automatically stretching and contract-

Fig. 10.

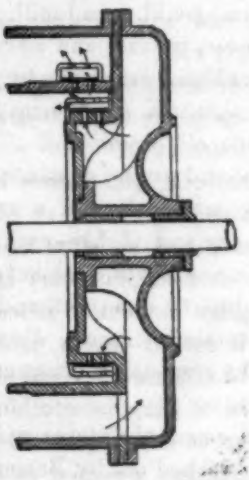
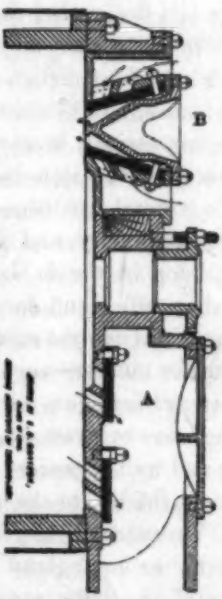


Fig. 11.



ing. These valves rapidly fail from the heat and stretching, even when the cylinder is cooled by water-jacketing, and they are somewhat inaccessible for repairs.

A modification of the blast-furnace flap-valve is more generally approved. Fig. 11 shows it as applied to a vertical Bessemer engine at the Cambria works. A are the ejection-valves. The induction-valves, B, have the smallest possible clearance and consequent waste of air.

The positive-valve motion—large piston-valves opened and closed by the engine—is being substituted abroad for automatic valves. This is an improvement, compared with the early Bessemer valve, Fig. 10, but it is costly, and it has its own peculiar difficulties. A good rubber valve (Fig. 11), $\frac{5}{8}$ inch thick, and resting on a grating with one-inch openings, is quite satisfactory, provided the access for repairs is good and the cylinder and head are water-jacketed.

There is a constant impression in the minds of capitalists, and even of general engineers, that any given iron- and steel-making machinery may be cheapened—that less heavy and less accurately fitted parts will do—that all this duplication is not absolutely essential—that masonry buildings, and iron roofs especially, are mere luxuries, and that it is better to make a little less product, and to take the risks of breakage and fire, rather than to pile a million dollars, before earning the first cent, into what may be called a complete steel rail plant, viz., four vessels and appurtenances, a blooming-mill, a rail-mill, a small merchant-train, and the necessary furnaces, fixtures and movables.

These impressions, however, are contradicted every day by the current history of the iron business. Competition springs up in more favorable mineral localities—what do the old works do? Tear out their old machinery and build better—and so, by producing more cheaply, keep in the field. The whole matter lies in a nut-shell. Works that will stand *hard crowding*, day and night—works where steam-machines can *get enough to do* to make it worth while to substitute them for muscle—such works cost less to construct, and to run, *per ton of product*, just in proportion to their bigness, always provided they do not grow out of reach of a reasonably compact, homogeneous and well-organized management.

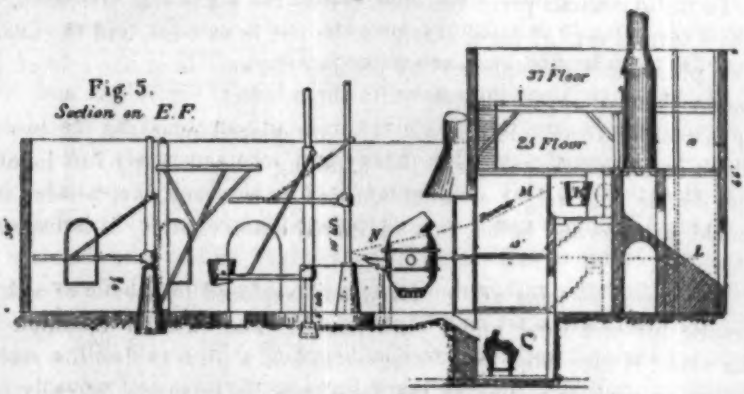
We come, finally, to the *general arrangement* of fixtures and machinery. The standard English plant, as worked out by Bessemer and still adhered to in England and on the Continent, excepting only in a very few of the later works, is shown in Plate V, by the side of the standard American plant now adopted, with a few changes in detail, in all American works. The American plant is farther illustrated by Fig. 12. This new arrangement is found necessary to a large and economical production.

Its most conspicuous feature is the arrangement of the vessels, especially their height above the general floor, and the consequent shallowness of the casting-pit. The English vessel centres stand only three or four feet above the general floor, and the bottom of the cast-

ing-pit must hence be eight or nine feet below it. In this confined, unventilated and comparatively inaccessible gulf the largest and the hottest manual work is performed. Here the steel is poured and the

Fig. 12.

Fig. 5.
Section on E.F.



red-hot ingots and moulds are handled. In the American plant, the vessel centres are nine feet above the general floor, and the pit is but 30 inches deep—just deep enough for convenient casting. All the operations of casting are performed, all the ingots and moulds are handled, by men standing on the general working floor of the building. Convenient access, free ventilation, and a short lift of moulds and ingots are thus secured. The high vessel also allows the removal of the vessel bottoms on the general floor; and there is a second story of working room, by means of the platforms around the vessels, at the level of their centres. The runners are accessible for repairs, and the vessel noses for the insertion of scrap, from this platform. When highly siliconized or hot irons are used, some steel scrap is put into the vessel cold, and melted as well as reconverted with the iron charge.

Placing the vessels side by side is not new. Bessemer did it in his early practice, but not in such a way as to realize the advantages we are considering. In the American plant the rear of the vessels is open to a floor in the cupola building from which they may be conveniently fired, and where the tuyere-boxes may be opened, the tuyeres repaired, and the vessel bottoms set. The converting-house floor under the cranes is thus clear for ladle repairs—12 to 15 casting ladles are required,—for storing ingot-moulds, and for other purposes requiring crane power. The vessel chimneys, standing in the

wall of the building, occupy no useful space; whereas in the English plant the vessel repairs and the vessel chimneys take up valuable room under the cranes, and the chimneys prevent the cranes from revolving through an entire circle.

In the American plant the diameter of the pit is also increased, to allow several sets of ingot-moulds to be put in at once, and the available pit room is also enlarged by placing the vessels at one side of it, rather than on opposite sides.

Instead of two ingot cranes three are placed over the pit, two of which command the vessels. For handling a hundred tons of ingots, and double this weight of moulds, twice over every day, besides the mould bottoms and ladles, this additional crane capacity is indispensable.

The vessel bottoms are removed and replaced by means of a hydraulic lift and a car under each vessel. The exterior trunnion of the vessel is supported by a beam instead of a pier, so that the vessel bottom or a whole section of the vessel can be removed laterally for repairs, after it has been let down upon the car by the lift. Both inner trunnions are supported on an iron or masonry pier. In some of the American works the hydraulic cylinder for rotating the vessel is arranged vertically, below the floor, as shown in Plate V, fig. 9, to save room as compared with the horizontal English cylinder.

In several American works now constructing, the vessel cylinder, Fig. 13, is placed above the trunnions, for convenience of repairs, and to allow a longer stroke and hence greater steadiness in the movement of the vessel.

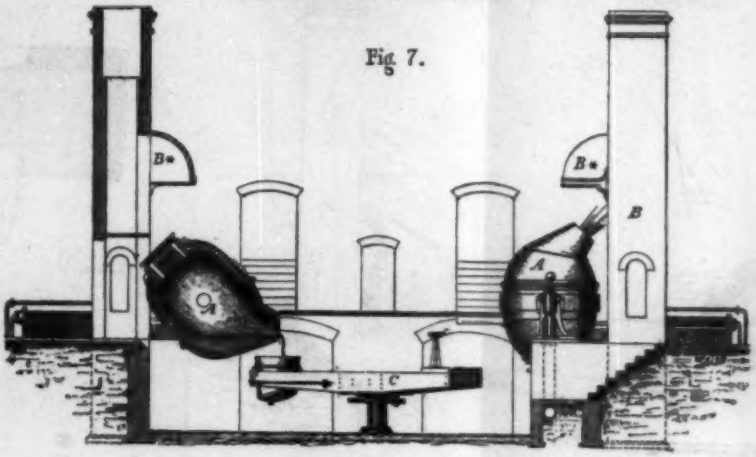
A front elevation of converters, thus arranged in the North Chicago Rolling Mill Company's works—the latest and most improved Bessemer plant started in America—is shown upon plate.

The plates show in detail the particulars and latest proportions of vessels and associated members. The upper and lower parts of the vessels are sections of cones instead of spheres, to save cost in construction. The cars under the vessels are moved by hydraulic cylinders.

When the steel is intended for rails—and 90 per cent. of that made in this country is so used—the charges are so regulated as to cast either eight or ten ingots, and a little over, as a margin for chilling and spilling. Each ingot makes two rails; it is usually 12 or 13 inches square at the bottom, tapering to 11 or 12 inches at the top—so as to slip out of the cast-iron ingot-mould,—and $3\frac{1}{2}$ to $4\frac{1}{2}$ feet long, weighing 1300 to 1600 lbs.

STANDARD ENGLISH PLANT.

Fig. 7.



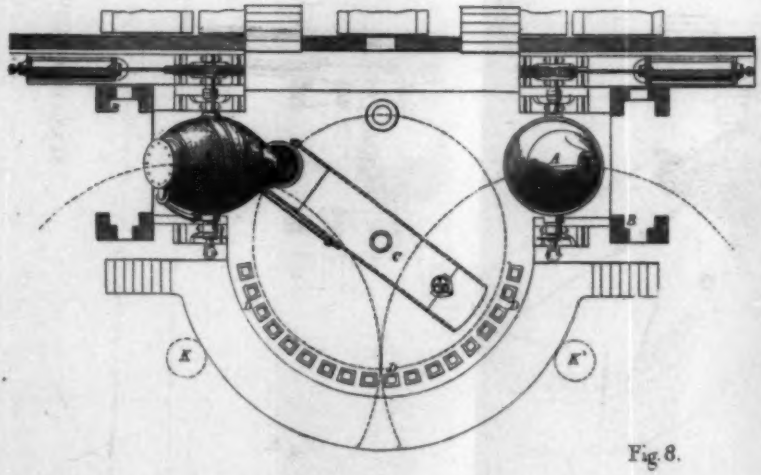
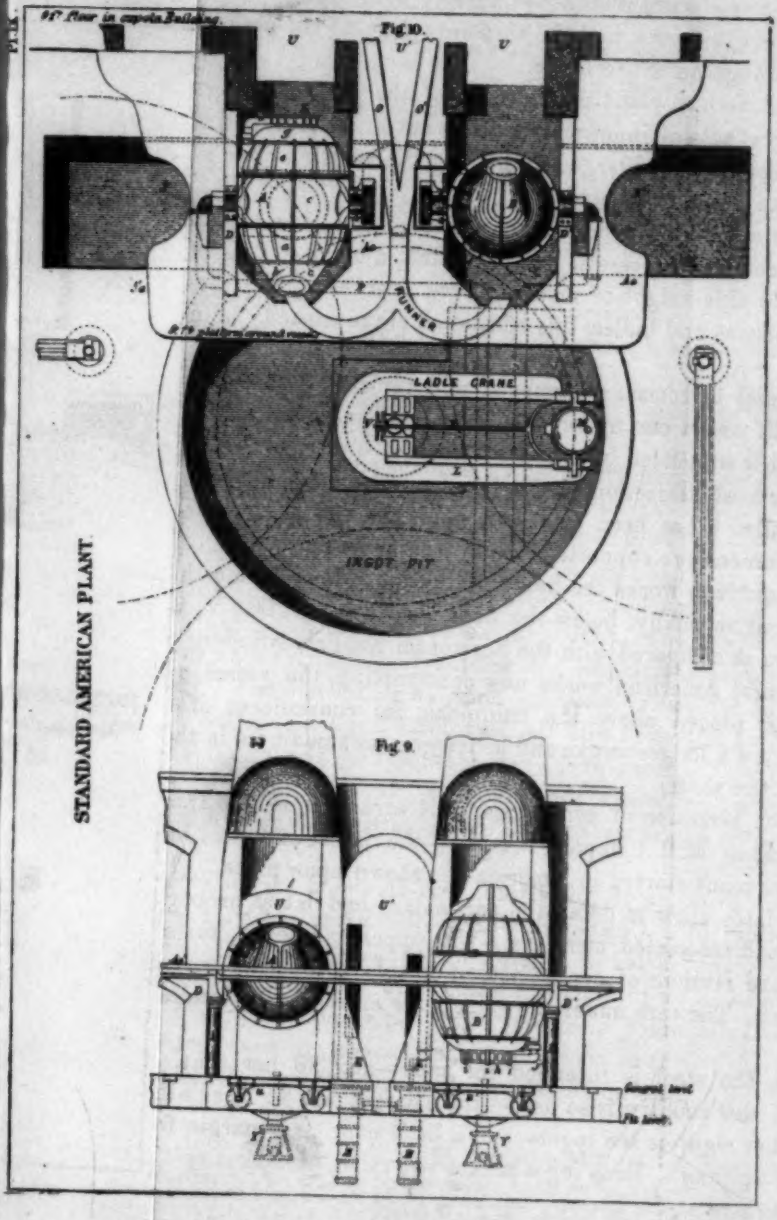


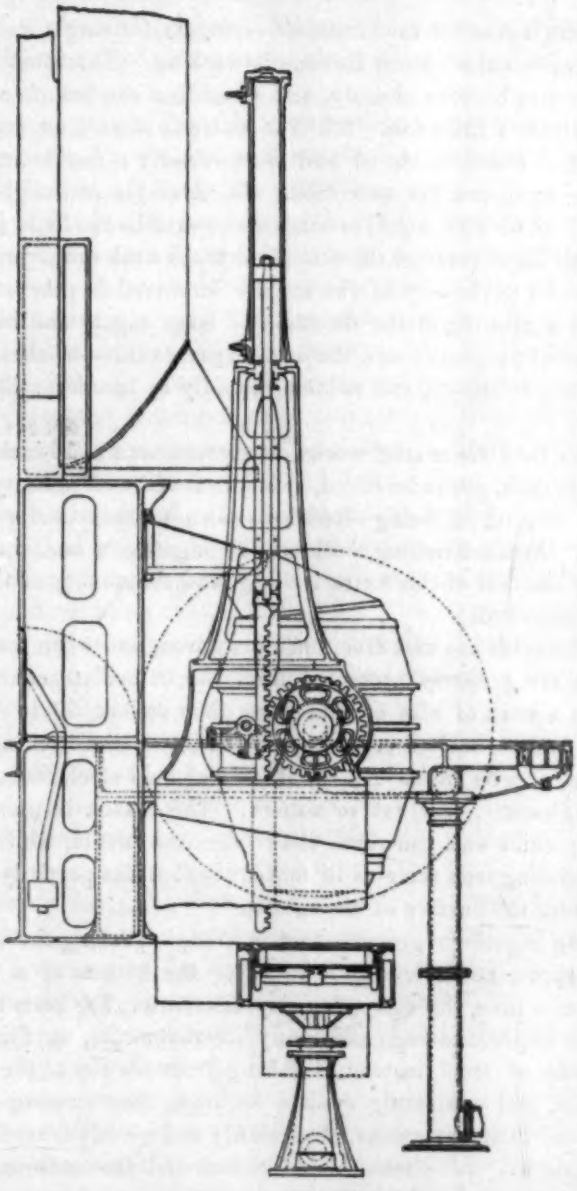
Fig. 8.



STANDARD AMERICAN PLANT.

The ingots are removed hot, each charge together on a car, to the blooming mill, and if any heating furnace is ready, they are charged

Fig. 13.



into it directly, thus saving much heat. They must be allowed to crystallize, however, before rolling. If the interior of an ingot is still pasty from the heat of conversion it will go to pieces in the rolls.

Double ingots are used instead of ingots for single rails, 1st, to save a repetition of manipulations in working. This must be done by machinery to be done cheaply, and a *machine* can handle a big ingot as quickly as a little one. 2d. The extreme top of an ingot is unsound, and must be cut off and reconverted; a double ingot yields but one scrap end for two rails. 3d. A single rail might be rolled from a 7 in. or 8 in. ingot, but the steel would be too little condensed; a 12 inch ingot receives three times as much work in the rolls, and the density and uniformity of the bar are improved in proportion. The practice is growing in the direction of large ingots and large reductions for all purposes; and the counterpart to this—to cheapen cost—is handling by steam, and reducing rapidly by heavier rolls and hammers.

At the Bethlehem steel works, now constructing, 16-inch ingots for four rails each, are to be rolled, at one heat and two re-heats, into rails 60 feet long, these being afterwards sawn to the standard length of 30 feet. Steam-handling, both at the ingot-rolls and the rail-rolls, will pay the cost of this extra heating, and the quality of the product will be improved.

Ingot-moulds are cast from open gray iron, and when their interior surfaces are properly protected from the immediate contact of the steel by a wash of clay or plumbago, they endure 50 to 100 heats. A large body of melted cast-iron, poured into a cast-iron ingot-mould, will adhere to its sides. An equal mass of fluid steel, though of twice the temperature, will not so adhere. The reason is that the steel instantly chills and contracts away from the mould, while the more slowly chilling iron remains in contact until it has partially fused and united with the surface of the mould.

Casting ingots in groups—that is to say—pouring the steel into a central sprue, and allowing it to enter the bottom of a number of moulds at a time, through a fire clay distributor, has been the subject of much experimenting, and many improvements, in this country. The stream of steel, instead of falling from the top to the bottom of the mould, and spattering against its sides, thus causing a cellular texture and incipient cracks, rises slowly and quietly from the bottom. The ingots are more smooth and sound, and the endurance of the

moulds is doubled. For small ingots, this system is indispensable; for large ingots, it is still on trial; but it is probable that the cost of moulding the distributing bottom will be more than compensated by the saving of unsound product. The best average practice in this country, with standard irons, does not yield above 2 per cent. of second quality rails.

By referring again to Plate I, we may observe some other features of the latest practice, the object of which is to economise labor and facilitate the handling of a larger product.

The two cupola hoists, a and b, fig. 2, one for coal and refractory materials, and the other for iron, are placed at the two corners of the building, in order to secure more working and storing room in the charging yard than when the hoists are side by side. The ground on three sides of the cupola building is thus utilized. All the varieties of iron of which a charge is composed, are mixed by weight, in charging wagons, by means of a charging scale with several independent beams. The wagon is run upon the scale; No. 1 iron is thrown in till No. 1 beam rises; No. 2 iron is then added till No. 2 beam rises, and so on till six or seven are mixed, without loss of time or risk of arithmetical mistakes. Hand wagons, holding one ton each, are preferred to railway cars of larger capacity, because the former are readily hauled by one man, and not being confined to a track with its switches and comparatively short curves, can be more conveniently manœuvred. The iron and coal are charged directly from their wagons to the cupolas—not dumped on the floor, as in common foundry practice.

When the cupola bottom is opened, after the day's work, the mass of slag and debris that had accumulated in it, slides down the incline below, and spreads out in a thin layer on the ground, where it is easily cooled and broken up. It is then carried to the cinder-mill, or tumbling-box, *c*, conveniently near, where the cinder is broken up and escapes in dust; the shot iron remaining is dumped into a wagon, ascends the adjacent iron hoist, and is again charged into the cupola.

A fifty horse engine for the fan-blowers, cinder-mills, and stone-grinding machinery, occupies the remaining ground floor at this end of the building. The opposite end is used for grinding and preparing ganister, clay and refractory mixtures.

Much ground room and some cost of construction are saved by placing the cupolas at such a height, that the metal charged into them will flow to the vessels by gravity, as compared with the plan of setting the cupolas on the ground, and raising the metal after melting.

The space under the cupolas and ladles is conveniently employed as storing-bins for tuyeres, stoppers, and such fuel and refractory materials as are used about the works in small quantities. The cupola building being higher than the surrounding buildings, its four sides are open for ventilation.

The cupolas stand directly on the 25 feet floor, instead of being raised on legs as in foundries. This avoids the necessity of separate platforms for tapping and for clearing out the tuyeres; and it entirely shuts off the heat, dust, and steam of the debris from the working parts of the building when the cupola bottom is dropped.

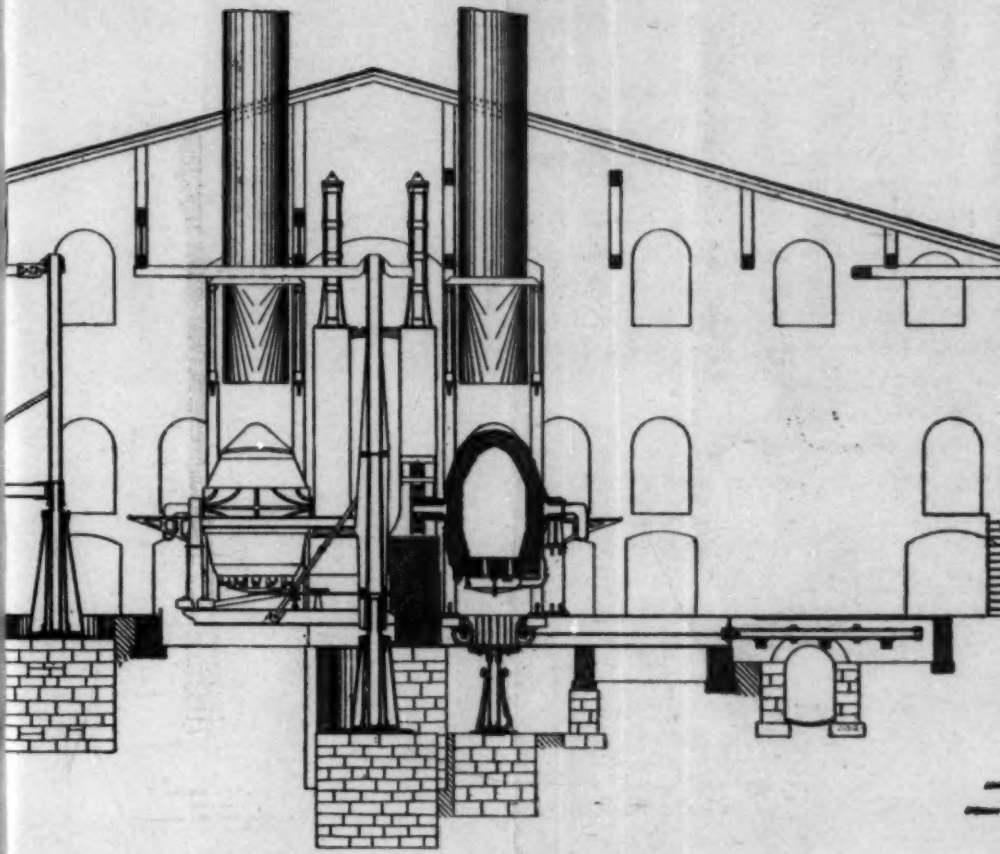
The slag from the vessels and casting ladles—some 20 tons per day—is dumped in the pit and quenched by a jet of water. Then, instead of being shovelled up to the general level—nine feet or more in the English works—and here shovelled again into barrows and wheeled away—it is, in the works here shown, thrown through openings behind the vessels down into a dumping-car, which, when filled, is run upon the coal hoist, lifted to general level, and drawn—by steam if preferred—to the dumping ground. The air and water pipes from the regulator to the vessels and cranes, also lie in this subterranean passage, where they are protected from frost, and accessible for repairs. Burying hydraulic pipes has been a costly experience in this country.

The floor, A, B, fig. 2, behind the vessels, on the general level, is made a thoroughfare for wagons or a railway, as convenience may require. The ends of the converting building are left open to the yard, so that a railway may run straight through, across the pit and under all the cranes.

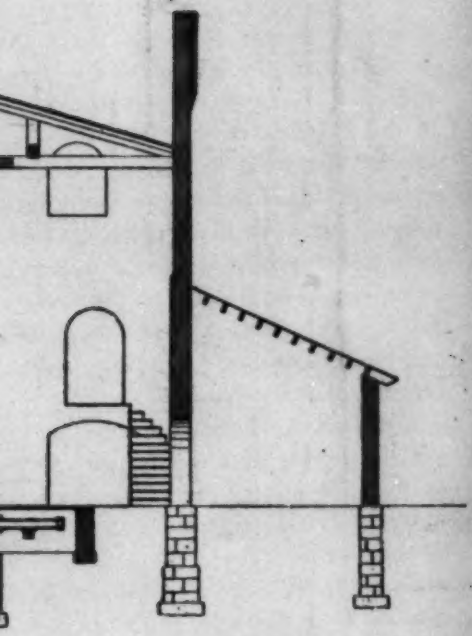
Ovens for drying vessel bottoms, ladle stoppers and clay and brick-moulds, when these are employed, are so arranged as to be commanded by the two side cranes.

Many minor refinements of arrangement and construction have been instituted in American works, and as the engineers of our great iron establishments are taking up the steel manufacture, we may confidently look for still other changes and economies in detail. It is probable, however, that the fundamental mechanical features so boldly and successfully brought forward by Mr. Bessemer, will always remain prominent.

I regret that our limited time has required such a hasty and perhaps inadequate consideration of the Bessemer manufacture, and the omission of many interesting features altogether.



Bessemer Machiery, Plate VI.



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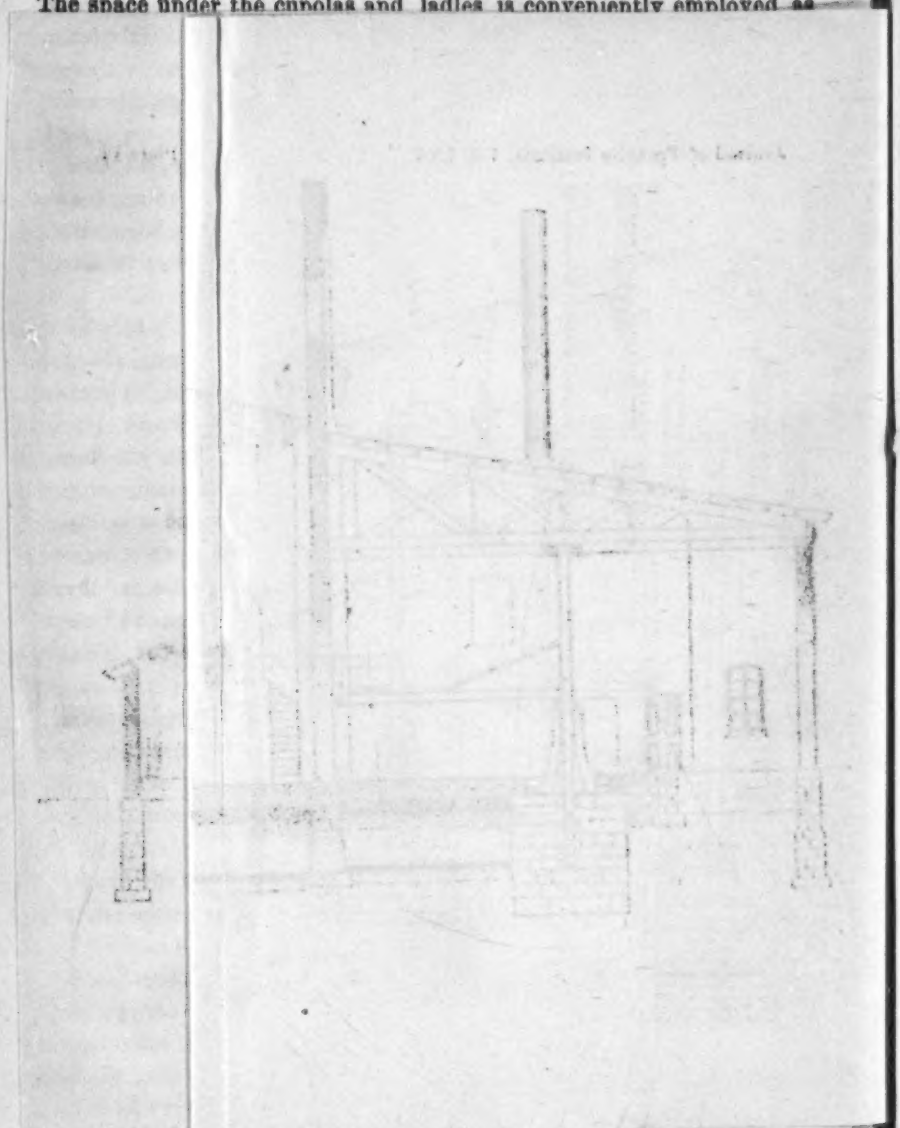

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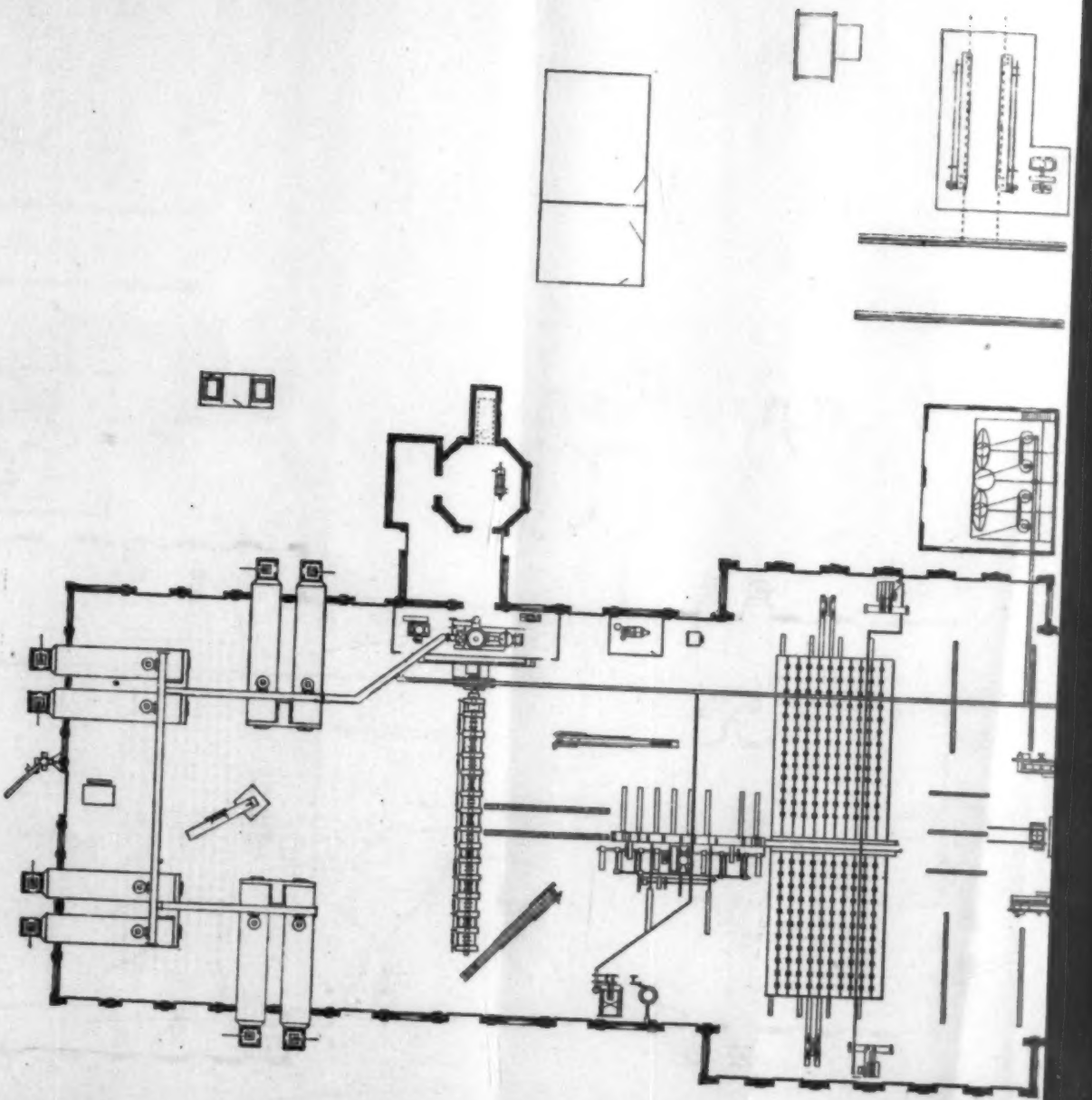
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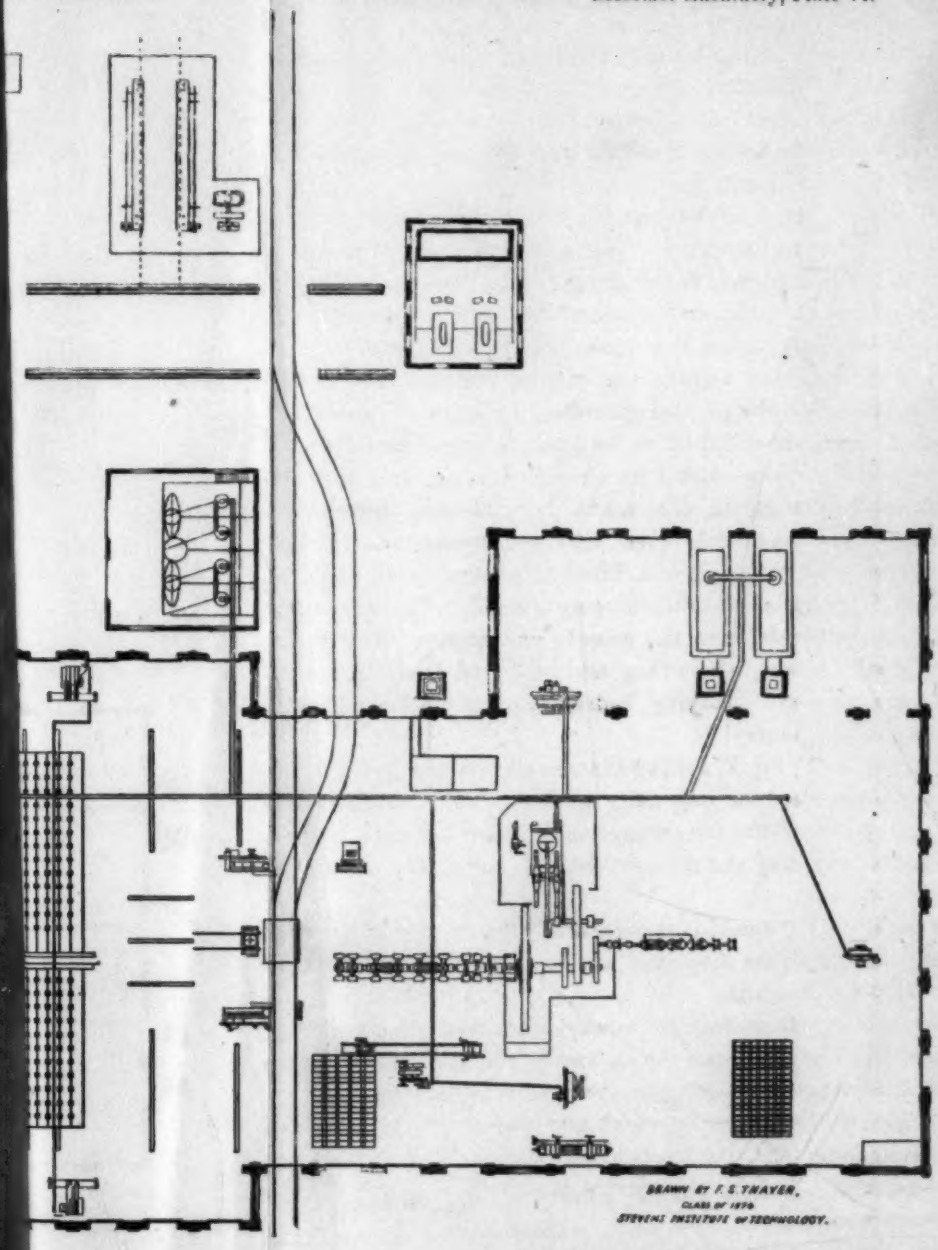
Bessemer Machinery, Plate VI.



DRAWN BY F. S. THAYER,
CLASS OF 1876
STEVENS INSTITUTE OF TECHNOLOGY.

Our chief object will have been accomplished, however, if the somewhat remarkable adaptation of this machinery to the work required shall have been made manifest, and more especially, if these considerations shall confirm to students in mechanical engineering the useful lesson that, while practice and precedent should never be ignored, there *are* occasions for radical innovations and new departures.

TESTS OF THE WORTHINGTON PUMPING ENGINE.

By William M. Henderson, Hydraulic Engineer.

The majority and minority reports upon the tests of the Worthington Pumping Engines at the Belmont Water Works, of this city, which took place nearly a year ago, having been laid side by side before the readers of the Journal, affords an excellent opportunity for comparison. I would propose an additional test, to ascertain which of these two reports is to be depended upon. The report of the experts and engineers appointed by the Councils of Philadelphia states that the engines performed a duty of 54,416,694, being 8·83 per cent. in excess of the guaranty; and these gentlemen have shown, by elaborate calculations, how that duty has been ascertained. The report of the expert and engineer, selected by the Citizen's Committee of Thirty, states that the engines, even under such favorable circumstances as surrounded this special test, only performed a duty of 44,679,000, or about 12 per cent. *less* than the duty guaranteed, and about 22 per cent. less than the finding of the experts appointed by Councils, and this gentleman has also given the figures used in the calculation to show how such duty has been ascertained.

Now they cannot both be right, and, as this is a matter that has occurred in the same city where the Franklin Institute Journal is published, which contains the said reports, and which Journal is received as the acknowledged exponent of American applied science, both at home and abroad, we are directly interested in the settlement of this doubtful question; the problem is exclusively our own, and we have engineers who can unravel it. The method pursued for determining what shall constitute the elements comprising the peculiar duty of these particular pumps has been enshrouded with unusual mystery, all of which will be enlarged upon hereafter.

Happily there is nothing mysterious about the term "duty" of a pumping engine. On the contrary, it is thoroughly understood by engineers all over the world. There is no special American "duty"

as different from English or Continental duty, and the method for ascertaining the duty of a pumping engine has become a universal standard. Of course, it must be so, or how could the performance of one engine be compared with another, if each party established a method of its own? The measure of coal, as one feature of comparison, has not always been the same. In the early Cornish examples the standard has been taken as a bushel of 94 pounds, while the later English examples base their calculations upon a hundred weight of 112 pounds, while in this country the general practice is to use the Conventional weight of 100 pounds. The comparison by foot-pounds will, however, always remain the same, and, knowing the measure of coals used, the comparison of duty between any two engines, no matter where erected, can be readily determined.

But to relieve us from any doubt as to what is meant by the term "duty" in regard to its application to these particular Belmont pumps, we have but to refer to an official letter, dated May 26th, 1868, written by the late Chief Engineer of our Water Department to Councils, upon the fulfilment of which was based the awarding of the contract for the engines here referred to. I quote from the letter as follows:

"I give below a tabulated statement of the duties of a number of engines *taken in all cases from annual reports* and other printed documents; *when the word duty is used, it refers to the number of pounds of water raised one foot high by the consumption of one pound of coal,* technically called 'feet-pounds;' the duty therefore will show the comparative economy of fuel consumed by each engine named.

"The *annual report* of the Charlestown Water Board for the past year gives the average duty of the Worthington Duplex Engines for the *whole year* as 679,690 feet-pounds. The average *annual duty* of our Twenty-fourth Ward direct acting Cornish engines was 530,400 feet-pounds. By this it will be seen that the duty of the Worthington Engines was 22 per cent. more than the annual average of the Twenty-fourth Ward Cornish, showing that there would have been a saving last year, had we used engines similar to those at Charlestown, of $2,644·76." (Vide Journal of Select Council, 1868, Appendix, 174, pp. 1239 to 1243).

The bid of the New York firm was $95,000, and that of the Messrs. Merrick $57,000 for the same work. Notwithstanding this very considerable disparity in cost, it was thought best by Councils, upon the recommendation of the Chief Engineer, and with the distinct understanding that the Worthington engine should perform an annual duty

of at least 679,690 foot-pounds, or 67,969,000 pounds of water raised 1 foot high by each 100 pounds of coal consumed, to award the contract to the builder of these engines.

Such being the inducements presented to Councils which influenced the awarding of this contract, it is a very simple matter to ascertain whether the promises then made have been fulfilled. Strictly speaking, the result of the test lately made does not enter into the question at all, being merely experimental, and conducted for a brief period only, to ascertain what the engines could be made to do under the most favorable circumstances, and which could not have been maintained in practice. As a ruling out of this manner of testing, we are expressly informed that the promised duty of 679,690 foot-pounds is to be derived from the results obtained during each *annual* run.

Taking, then, the *annual report* of the Chief Engineer of the Water Department, presented to Councils February 8th, 1872, being the first one containing the history of the working of the engines under discussion, we find upon page 20 the following data, which enables us to arrive at the annual duty for 1871.

$$\text{Duty} = \frac{\text{Total gallons pumped during the year.} \times \text{Weight of 1 gallon.} \times \text{Height in feet.}}{\text{Total coal consumed,}} \times 100$$

$$\frac{1{,}054{,}210{,}990 \times 8{\cdot}34 \times 208}{4{,}816{,}309} \times 100 = 37{,}970{,}173,$$

or about 79 *per cent. below the standard.*

For the single month of January of last year, the duty was 37,884,657. The average duty of April last year was 39,232,500.

The annual duty for the past year (1872), was 39,619,801 (see page 40 of the Annual Report of the Chief Engineer of the Water Department, presented to Councils January 30th, 1873), and from the figures given to and published in the daily papers of this city, we find the duty for the month of January of the current year to be 38,167,700, so that now the duty of these engines is pretty well established; with these figures before us, it would seem that the annual duty of 67,969,000, the only matter of interest to our citizens, has not nor cannot be obtained.

Now, admitting the duty given by the majority report of the Committee which conducted the late experimental test, viz., 54,416,694, we have still a deficit of 13,552,306 pounds of water *not lifted*, or about 25 per cent.

The notable objections urged to the manner pursued by the experts and engineers appointed by Councils to test the Belmont engines, are as follows:

1st. The manner in which the coal was selected, screened, picked and stored exclusively for the test, instead of pursuing the course of daily practice, is pointed out without comment.

2d. The manner pursued in charging the furnaces with heavy, clean fires before the test began, sufficient in themselves to run the engines for a considerable time without addition, of which no account was taken—the usual practice being to run the fires down as low as possible, without actually stopping the engines, at the commencement of the test, and running the engines at the close of the test until they arrive at the same condition, and then stopping them.

3d. The manner of running the fires down at the close of the experiment, and leaving them in an impoverished condition.

4th. Allowing the engines credit for 9·5 lbs. of water evaporated per lb. of coal consumed, when the evaporation was only 7·5 lbs. This excessive evaporation allowed being rarely attainable in practice, the usual course pursued in such cases furnishing no precedent, the result is of no practical value, being purely hypothetical.

5th. Calling one-third of the ashes *coals* (1450 lbs.), and crediting the engines with that amount. Objected to because coals so small as to pass through the bars must, from that fact, be classed with the refuse. If there was this large amount of coal actually there, what prevented it from being turned to account?

6th. Forcing the engines continuously beyond their safe working stroke to within the dangerous proximity of five-sixteenths of an inch of the cylinder heads, as this could not be maintained except (as was the case here) by the superhuman exertions of two attendants sent by the builder of the engines to manipulate them.

7th. Irregularities detected by several witnesses in the manipulation of the feed-pump which supplied the boilers with water, allowing it to run slowly, feeding water to the boilers of which no account was taken, thus taxing the evaporative power of the boilers without giving due credit.

8th. Error detected by the citizens' expert in the measurement of the water delivered over the weir.

9th. Basing the calculation of capacity of the pumps *independently of the actual delivery of water into the reservoir*, which is about equal to enacting the tragedy of King Richard the Third with the character of King Richard omitted.

10th. Calling the height of the force main 217·74 feet instead of 208 feet, which it actually is. This, in effect, is giving the pumps

credit for mal-construction and insufficiency of water-ways; for it is clear that, if the friction entailed by the passage of water through a pump is to become an element of its duty, then the worst made pump —that in which the passages are distorted, and the water-ways throttled—will perform more duty (labor harder) than a properly constructed pump, having ample and direct water passages; and as the index of the pressure-gauge vibrated continuously from 5 to 8 lbs. at each stroke in these Belmont pumps, it is rather too much to expect that engineers will sanction that the signal defects of a machine are to be counted as elements of its virtues. This is altogether opposed to Cornish practice, or common-sense.

11th. The manner of running the water down in the steam-boilers to a lower level than it was at the commencement of the experiment is objected to, as this was, to say the least of it, unscientific, and has given rise to unnecessary discrepancies, which practically vitiate the conclusions arrived at in the report of the experts appointed by Councils, who state the deficiency in water level to have amounted to 530 pounds of water. They also state the evaporative power of the boiler to have been 8·19 lbs. of water per pound of coal, and give the amount of coal necessary to raise the temperature of this 530 lbs. of feed-water from 130° to the temperature of steam at 48 pounds pressure at 10 lbs. Now, as this is, to all intents and purposes, the same as that required to evaporate it—and we are told that one pound of coal did evaporate 8·19 pounds of water—this 10 lbs. should have been 64·7 pounds of coal. On the other hand, the minority report gives the deficiency in water as equal to a weight of 2,961 lbs., and required a consumption of 357 pounds of coal to restore. Correcting this allowance and that due to the altered state of the fires at the close of the experiment, together with the fact of increasing the stroke of the engine 2·74 per cent., and granting the whole displacement of the pump-plungers, the duty is reduced from 54,416,694 to 47,365,000, as derived from the following formula:

	Displacement in pounds.		Number of strokes.		Height in feet.
Duty,	679	×	139,604	×	217·47 × 100

Total coal consumed, 43,522 = 47,365,000.

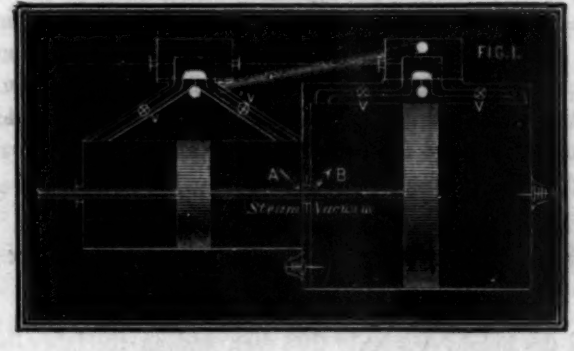
But, as the height was only 208 feet, and as the late Chief Engineer gave us to understand "*when the word 'duty' is used it refers to the number of pounds of water raised one foot high by the consumption*

of one pound of coal," the duty would be, allowing 3·8 per cent. for leakage, 43,591·000.

And this is only an experimental duty, which dwindles into utter insignificance when contrasted with some others obtained from the Cornish engines, to wit:

Fowey Consuls,	. . . .	50 inch,	130,200,000
Holmbush,	. . . . .	80 "	122,400,000
United Mines at Guennap,	. .	80 "	128,000,000

On the Probabilities of the Case.—The science of engineering being as readily taught to an apt pupil as any other branch of popular education, a person so taught will be able to discover the merits of a machine by an inspection of its design, and will be able to pronounce what general results may be expected from a machine so represented. Such being an established practice, recognized by the readers of the "Journal," who certify their faith in it by subscribing to this periodical, which only conveys to them plans and descriptions of machines they may never have seen and probably beyond the reach of personal inspection, I will avail myself of this current method by producing a cut representing the design of steam cylinders used in the Belmont engines. Each individual reader will then be able to decide for himself what there is in the arrangement that would be likely to produce a duty in the neighborhood of 68 millions of pounds of water raised one foot high by the consumption of one pound of coal, as we were promised, and whether the duty *actually* performed, 39 millions, is not about as much as could reasonably be expected.



A is a high pressure cylinder, or measure of expansion for B, which is the low-pressure cylinder. Double steam ports are provided at the

ends of each cylinder, the outer ports being in all cases the ingress, and the inner ports the egress, with regulating valves, V, between the two, as shown. A stuffing-box has also to be maintained in the head dividing the two cylinders, for the piston-rod to slide through, and a transfer-pipe, C, proceeds from the exhaust port of cylinder A, to the steam chest of cylinder B, for transferring the steam to be expanded from the one cylinder to the other, *the ratio of expansion being limited to three times.*

The manner of cushioning the engines at the ends of the stroke is effected by the pistons travelling over the exit ports some distance before the completion of the stroke, and entrapping a portion of the steam to cushion upon, which is gradually permitted to escape by the outer ports (never covered by the pistons) to the exit ports again, by adjusting the regulating cushion-valves, V, placed between the two for this purpose. In addition to these, other valves are inserted in each head of the low-pressure cylinders, the stems of which project inwards; they are kept to their seats by springs. Live steam from the boiler is supplied to the back of them. Now, in case the cushion valves just described do not act properly, the piston, in going to the limit of its stroke, will strike these open and admit a rush of steam upon the surface of the low-pressure piston, which of course will effectually stop it. It will be observed there are six cushion-valves to each engine, and twelve to the pair, besides which there are employed three throttle valves, introduced in the transfer and exhaust pipes.

The writer considers it a duty to place the subject of the test of the Belmont pumps in its proper light before the community, since erroneous statements once appearing in print are frequently reproduced, either by the design of interested parties or, perhaps from the unusual character of the merits of a machine so portrayed, and much damage may accrue from this if not corrected. All that I have essayed to do in the premises is to place the matter in its true light, as gleaned from the two reports, and leave the mooted subject for the just decision of our mechanical readers.

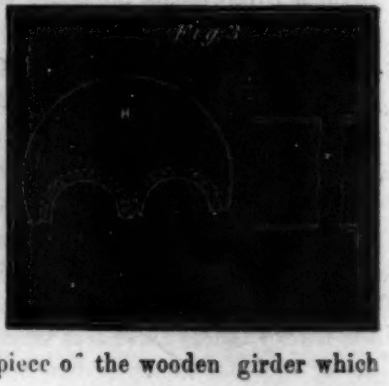
Philadelphia, Feb. 27, 1873.

ON THE STEAM-BOILER EXPLOSION AT THE ROLLING-MILL OF J. WOOD & BROTHER, CONSHOHOCKEN, PA.

By W. Barnet Le Van, Engineer.

The above works are situated on the west side of the Reading Railroad Company's track, and just below the bridge which crosses the same. The building covers a space of 100 by 200 feet. About one-half the works were destroyed by the accident, the upper end being a complete ruin, in which sections of the roof of the destroyed building, bricks, pieces of iron plates, twisted rods, bent bolts, lay in one confused mass. There were in the mill seven boilers, each being separate and distinct. The one that burst was at the northern end of the building, and its course was directly west across the canal.

The Exploded Boiler had been in use for nearly twenty years. When the rupture took place it was lifted from its settings, and shot across the canal like an immense projectile forced from a cannon, at about the same height as its original position, until it reached the building, 150 feet distant on the other side of the canal, known as the Albion Print Works. This immense mass, weighing about 5500 pounds, struck the end of a girder, twelve inches square, over an arched doorway, shattering the same, and tearing away the wall, and bringing up against a large cylindrical vessel of wrought iron, 8 feet in diameter and 12 feet high and $\frac{7}{16}$ of an inch in thickness, called a Kier, in which at the time were two lads, George Smith and James McNulty, who were arranging the pieces of endless muslin within by tramping them down so that the steam and lime-water, which were to be subsequently let in, would not mix up and entangle the material —the only mode of ingress or egress being a small man-hole on the top of the vessel. The two poor little fellows were tramping away when the end of the flying boiler came in contact with the sides of this kier. The heavy iron sides gave way before the shock like wetted paper—the indentation, nearly reaching the opposite side, instantly killing both lads, George Smith being actually cut in two. The force and impact of the blow of the flying boiler was so great that the piece of the wooden girder which

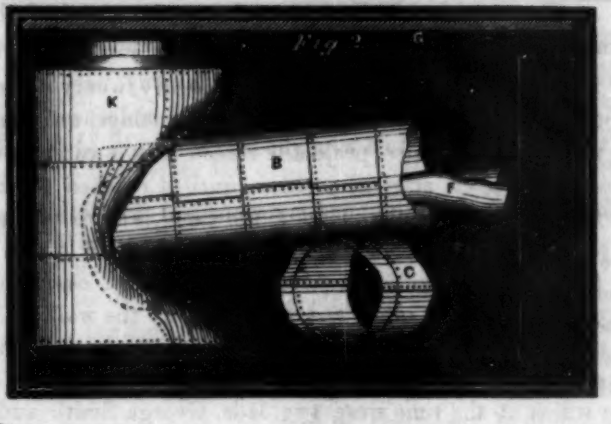


it carried with it was ground into splinters, and the atoms, being packed so closely together, were ignited by the friction that they burst into flames, setting fire to the material contained in the kier.

In the mill where the boiler stood eleven persons were killed and as many more wounded.

Nothing was left of the boiler at its original location except about two feet of one of the flues, the mud-drum and two-thirds of the back-head, H (cut 3).

The balance, consisting of the shell containing the two flues, lodged as above stated, in two pieces, as per sketch:



K, Kier.

B, Shell of boiler, contains the two flues, about 14 feet long.

C, Shell of boiler, about 4 feet long, open on both ends.

F, Flues.

Shell B represents the boiler with one end resting in the indentation of kier, the other end supported by a piece of the shell, C, about four feet long, 54 inches diameter, at right angles to shell B. After the boiler was removed, the hole in the side of kier was found to be about three feet in diameter.

The construction of the boiler is shown by the following cut:

Description of Boiler.—The boiler consists of a cylindrical shell, eighteen feet in length and fifty-four inches in diameter, and contains in its lower half two flues, each eighteen feet long and sixteen inches in external diameter, secured to the heads with angle iron rings. To the bottom, about three feet from the back end, was attached a mud-drum, eighteen inches in diameter, seven feet in length, by a pipe six

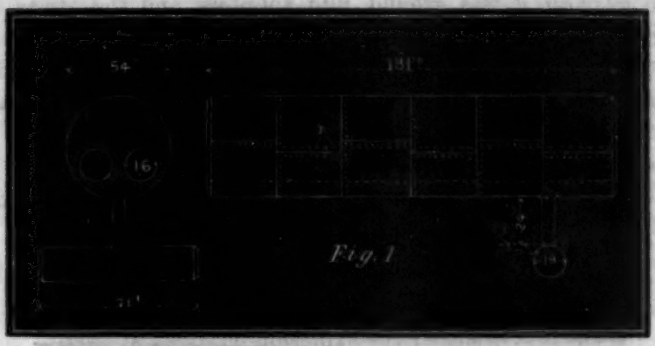


Fig. 1

inches in diameter and twenty-four inches long, into which the feed-water was pumped. It was set, in the usual way, over the heating furnace, the waste heat of the latter passing underneath the shell, thence, through the flues, to a wrought-iron stack placed over the front end.

The following are its principle dimensions and proportions, namely:

Extreme length, in feet,	18·
Diameter of shell, in inches,	54·
Number of flues,	2·
Extreme length, in feet,	18·
External diameters of flues, in inches,	16·
Extreme length of mud-drum, in feet,	7·
External diameter, in inches,	18.
Thickness of iron in shell, in inch,	·259 = No. 3.
Thickness of iron in flues, in inches,	·238 = " 4.
Thickness of iron in heads, in inches,	·454 = " 0000.

The safety valve was three and one-half inches in diameter, and in good order when found, after the explosion, as also was the three-inch stop-valve, the latter being closed. This valve was placed between the boiler and the main line of steam-pipe which conveyed the steam from all the boilers to the engine.

The flues at the point of rupture were but three-sixteenths of an inch in thickness, and as clean cut as if done with a pair of shears, allowing a ring of metal remaining in the angle iron ring, which secured the flues to the head as though it was so ordered. The flues were flattened together as though they were passed through a pair of rollers.

The iron composing the flue plates was very much crystallized at the point of parting, no doubt caused by the constant expansion and contraction; and there is no doubt but a certain amount of this crystallization was due the use of angle iron rings to connect it to the heads; the flue plates would not flange from its being *hot short* iron.

The boiler had been out of use for a few days for repairs, and they were in the act of getting up steam at the time of the explosion.

The Engineer's Statement.—The engineer testified that he had observed the fireman firing up at about two o'clock in the afternoon; the blast was put on the furnace at half-past two, another man having succeeded the first fireman; the explosion occurred at twenty minutes past four, the blast having been on the furnace until that time; there was no unusual forcing of the fires; witness had in the meantime tried the gage-cock and water-gage; usually carry about from eighty to eighty-five pounds on the gage; had about fifty pounds on about ten minutes before the explosion; never knew the safety-valve to stick; carried the weight on the lever of the safety-valve at about eighty-five pounds, at which pressure the boiler would blow off; noticed nothing unusual about the boiler; there had been no water in the boiler until the day on which the explosion took place; he pumped the water into the boiler right out of the river; there was no water in the boiler until half-past twelve on the day of the explosion; it generally took about three and a half hours to generate steam enough to run; the man who took the place of the one that fired up in the first place is among the killed; the boiler was nearly full of water; it blowed water from the top gage-cock; never was in the habit of hanging any weights on the safety-valve lever.

In answer to a question of a juryman, the engineer said that, to the best of his knowledge, there was not more than 55 or 60 pounds of steam pressure when the boiler exploded.

The Verdict.—"That the deceased (names mentioned) came to their deaths by the explosion of a boiler in the rolling-mill of J. Wood & Brother, in the above borough (Conshohocken), and, in the opinion of the jury, said boiler had by long and continued use become, in certain parts, inadequate to carry the required pressure, viz., eighty pounds."

Strength of the Boiler.—The shell of the boiler would have parted at 322 lbs. per sq. inch, taking the value of the plates, single-riveted, at 33,600 for its elastic limit. The *working pressure* should be, for safety,

at least one-sixth of the above, say fifty-three and one-half pounds per square inch. The flues would have collapsed, by Fairbairn's formula, at a pressure of one hundred and forty pounds per square inch, the safe working pressure being only twenty-three pounds. The shell, as will be seen by the above, is about two and one-half times the strength of the flues. The working pressure of the boiler, as stated by the testimony of the engineer, having been eighty-five pounds per square inch.

The Cause of the Explosion.—The cause of the explosion is therefore obvious, viz: weakness of the flues. No flues of such dimensions as those just given can be safely worked with steam at a pressure of eighty-five pounds per square inch, unless strengthened either with hoops or flanged seams, or stayed in some other suitable manner. It may be true, however, that some such flues, though unstayed, are working, and have done so for years with steam of an equal or even a greater pressure than the above; still they are continuing to do so only at a risk; and their past exemption from collapse is no security against its occurrence in the future. Thus it will be seen that the above explosion occurred from the most simple cause, and that no mystery whatever need be attached to it, while, by suitable construction of the boilers in the first place, and due attention to their state of repair in the second, explosions would in most cases be prevented.

Very few of the explosions that have come under my notice occur from low water, and I believe that to be a much-abused idea, and the number of explosions resulting from it to be much exaggerated. At inquests it is the general verdict, and the fireman being frequently killed, there is seldom any witness to the contrary. The greater number of explosions occur from the insufficiency of the boiler for its working pressure, either on account of its original construction, or state of repair consequent upon use; where it occurs from want of water, or from reckless pressure, explosions are rare. The majority of explosions are due more to the weakness of the boiler than to over-pressure of the steam. There is no plan of testing the construction or weakness of a boiler, either new or old, equal to the use of hydraulic pressure; its application is so simple, and the pump so small, that every boiler owner could at a small cost provide themselves with one. In fact the ordinary feed-pump could be used temporarily for that purpose and should be applied at least once a year. Weak places in the plates may pass undetected, even on careful examination, while some parts may be inaccessible and concealed from view; but the hy-

draulic test is sure to detect and expose them all. Its application in this case would no doubt have prevented this disastrous explosion.

The Examination of Boilers.—In all examinations of boilers, it should be done in person with the free use of a round-nose hammer on all the stays and flues, and when this has been done in a thorough manner, the hydraulic test should then be applied.

This is what you pay to have done in the case of the Boiler Insurance Company, should you apply to them for a policy of insurance on your boiler. The first outlay for this purpose would furnish you with a test-pump and the necessary appliances to repeat it every six months at a nominal cost; in fact, every one should be able to take his own risk.

Safety Factor.—In conclusion, I would call the attention of the Institute to the factor of safety for boilers as being entirely too low. The great number of disastrous explosions that have lately occurred in different parts of the country are the best evidences of the fact. The Bridge Engineers have long since come to this conclusion, and have fixed their factor of safety at one-eighth the ultimate value of the material.

The elastic limit of wrought iron of high quality is 33·600 pounds per square inch, making an allowance for the loss by rivets of ·56 per cent., we find for the elastic limit of a boiler shell that the factor would be 18816, or 33·600 pounds × ·56.

All experience has shown that but one-quarter of the elastic limit, say 5000 pounds, making all allowances for rivets or attachments, is all that ever should be used in practice.

February 19, 1873.

A Large Aneroid.—An immense aneroid barometer is about to be placed on the façade of the Paris Bourse. The portion, however, of the instrument which is sensitive to the various pressures of the atmosphere is no larger than the ordinary sized aneroid. The movements of the corrugated plate are transmitted to a train of clock work, by suitable mechanism. This last, which is wound up monthly, actuate a great needle on the exposed face, the latter being four feet in diameter.

TORSIONAL RESISTANCE OF MATERIALS DETERMINED BY A NEW APPARATUS WITH AUTOMATIC REGISTRY.

By Prof. R. H. Thurston.

While the classes of the Stevens' Institute of Technology were recently engaged in their revision of coëfficients, as given by various authorities on strength of materials, the difficulty of determining how far the differences noted were due to errors of observation, and how far to variation in the quality of the materials used, suggested to the writer the advisability of obtaining an apparatus which should make its own record. This could readily be done by so constructing it that a curve might be automatically registered at each tests, which should represent all circumstances of the experiment.

Such an automatic registry would evidently yield more reliable and instructive information in regard to the circumstances of distortion and fracture than could any system of personal observation.

Representing the magnitude of the distorting stress at every instant, and under every degree of distortion of the material, up to the limit of elasticity or even to the point of rupture, and exhibiting also the corresponding alteration of form at every point, the pencilled curve would be a record from which might be deduced the coëfficients of elasticity, strength and resilience, as well as the laws governing the relations of the distorting forces to the resistance of the material.

A simple but effective machine was therefore designed and constructed, which accomplishes satisfactorily the desired result, and this machine, as planned by the writer and constructed by Messrs. Hawkins & Wales, instrument makers to the Institute, is shown in Fig. 1.

As here arranged, it is intended for experiments on the torsion of materials. Its modifications, for the purpose of experimenting upon transverse strength, will be described in a subsequent paper, in which will be given the results of that series of experiments.

In the figure, the frame, A A, A′A′, supports two suspended arms, C E, B D, which swing about independent axes in the same line. The arm, B, carries at its extremity a weight, D, and the arm, C, has a handle, E, by which it is moved. The axes of these arms are designed as shown in Fig. 2, each having a rectangular recess at L and at M, which receive each an end of the test piece, which is squared to fit, as shown in Figs. 3 and 4.

The frame, A′A′, carries a guide curve, F, of such form that its ordinates are proportional to the twisting moments exerted by the

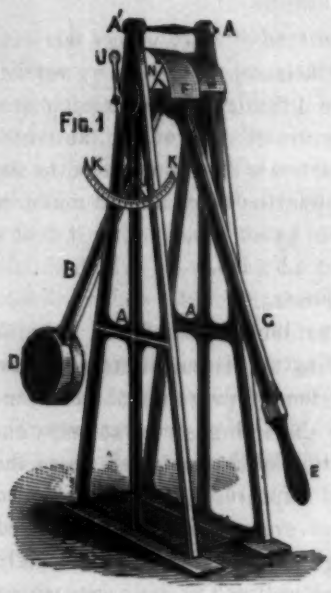


Fig. 2

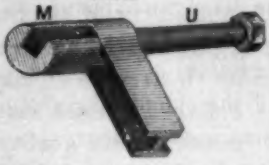


Fig. 3

Fig. 4

weighted arm, B D, while swinging through the arc to which the corresponding abscisses are proportional. A pencil holder, I, bears against this guide curve, and, being carried by the weighted arm, is thrown forward, as that arm swings out under the action of the force producing torsion, which force is transmitted through the test piece.

The arm, C E, carries a table, G, and the pencil, I, therefore, traces upon the paper, which is clamped upon it, a curve, the ordinates of which are proportional to the torsional moments, while its abscisses represent the relative motion of the two arms, and, consequently, the amount of torsion to which the test piece has been subjected.

The curves thus described, of which the accompanying plate exhibits a number, present, in a very legible and convenient, as well as reliable, form, all the results of the experiments, of which they are the respective records.

The pointer, J, traversing the arc, K K, is arranged as a maximum hand, and affords a useful check upon the automatic record of maximum strength.

The plate represents the results of average experiments made upon a considerable number of varieties of wood, the test pieces of the form shown in Fig. 3 being used. The diameter of the neck of each piece was seven-eighths ($\frac{7}{8}$) of an inch.

This diameter happened to be that best adapted to use in this machine. A larger size was found, frequently, to yield by the destruction of lateral cohesion, the square head peeling, leaving a prolongation of the cylindrical portion, instead of twisting off in the neck. This size is convenient, also, in consequence of the fact that the coëfficient of ultimate strength for the standard diameter of one inch is obtained, with a close approximation to exactness, by simply multiplying the twisting moment for each piece by 1·5.

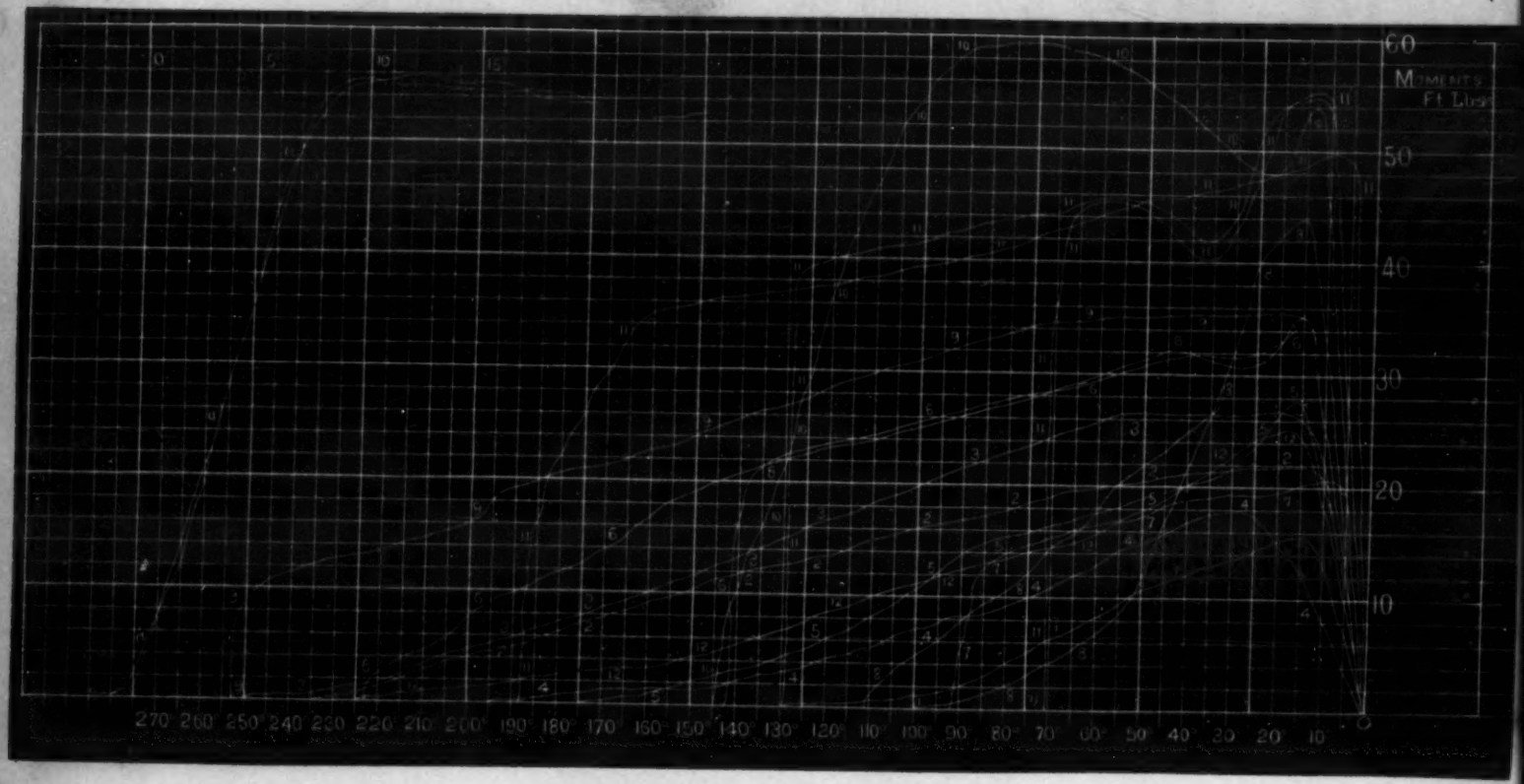
These curves exhibit the relative stiffness, strength and resilience of the woods tested very perfectly. The inclination of the straight line, forming the first portion of each diagram, from the vertical is a measue of stiffness; the height of the maximum ordinate indicates the ultimate strength; the point at which deviation from this straight line commences, determines the limit of elasticity, and the area included within each diagram is proportional to the torsional resilience of the test piece.

The fact that the commencement is, in each case, almost a perfectly straight line, is well exhibited in the curve, a a a, of locust, where the horizontal scale is purposely magnified, justifies the usual assumption that, up to the limit of elasticity, Hooke's law is correct, and that the angle of torsion is proportional to the twisting moment.

The short curve of small radius, noticed at the foot of the straight portion of each line, is produced by the slight yielding of the test piece by crushing, where it is grasped by the machine, which yielding continues until a firm hold has been secured.

It will be observed that, in most cases, the torsional resistance increases with the total angle of torsion up to a maximum, then, passing the limit of elasticity, it drops off more or less rapidly, returning finally to zero. In the brittle woods, the fall takes place suddenly, while, in the tougher and more elastic varieties, the resistance decreases very slowly, in some cases vanishing only after the test piece has been twisted through a very large angle.

In the case of black walnut, 6, 6, 6; locust, 11, 11, 11, and, in a still more remarkable manner, in that of hickory, 10, 10, 10, a striking peculiarity is exhibited, which is one of the most interesting and unanticipated developments of this series of experiments. In these


60
Moments
Ft. Lbs.
50
40
30
20
10
0
270 260 250 240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

curves the resistance increases with the amount of torsion, until a maximum is reached; the line then drops to a point considerably below, and thence again *rises* and passes another maximum, which, in the case of hickory, is only reached after a torsion of 75°. The resisting moment there becomes considerably greater than at the limit of elasticity.

This striking peculiarity was shown, by carefully repeated experiment, to be due to the fact that, in those woods in which it was noticed, the lateral cohesion seemed much less, in proportion to the longitudinal strength, than in other varieties. Watching the process of yielding under stress, it could be seen, by close observation, that, in the examples now referred to, the first maximum was passed at the instant when, the lateral cohesion of the fibres being overcome, they slipped upon each other, and the bundle of, then, loose fibres readily yielding, the curve dropped until, by lateral crowding, further movement was checked and the resistance again rose until the second maximum was reached. Here yielding again commenced, this time by the breaking of the fibres under longitudinal stress,—under that component of torsional stress which takes a direction parallel with that of the fibres in their new positions. In these cases rupture seems never to occur by true shearing in the transverse plane. The fibres part, one after another, the exterior ones breaking first, under a tensile stress.

The following varieties of wood have been subjected to torsional fracture, and the curves obtained are shown in the plate which illustrates this article:

1. White Pine, (*Pinus strobus.*)
2. S. Yellow Pine (*Pinus australis*), sap wood.
3. " " " " heart wood.
4. Black Spruce (*Abies nigra*).
5. Ash (*Fraxinus Americana*).
6. Black Walnut (*Juglans nigra*).
7. Red Cedar (*Juniperis Virginianus*).
8. Spanish Mahogany (*Swietenia mahogani*).
9. White Oak (*Quercus alba*).
10. Hickory (*Juglans alba*).
11. Locust (*Robinia pseudo-acacia*).
12. Chestnut (*Castanea esca*).

The curves, the *fac similes* of which are given in the plate, exhibit

well the relative values of the materials tested for the various purposes to which they may be applied.

White pine, 1, 1, 1, yields quite rapidly as the torsional moment increases, and the considerable inclination of the line from the vertical indicates its deficiency in stiffness. It soon reaches the limit of elasticity, and the diagram exhibits the maximum strength of the test piece, 15½ foot-pounds. Passing the limit of elasticity and the maximum moment of resistance almost simultaneously, its resisting power decreases rapidly, and with tolerable uniformity, until, at "a total angle of torsion" of 130°, it is twisted completely off. The area comprised within the curve is comparatively small and it is thus shown to have little resilience.

Yellow pine, in accordance with our already well established ideas of its properties, is found by an examination of its curve, 2, 2, 2, 3, 3, 3, to have much greater stiffness, strength and resilience. The sap wood, 2, 2, 2, is equally stiff, in the examples tested, with the heart wood, 3, 3, 3, 3, but sooner passes its limit of elasticity, the former circumstance being quite opposed to the preconceived ideas of the writer. Notwithstanding the comparatively low position occupied by the pines in our list, they are excellent materials, the yellow varieties particularly, for general purposes. Our comparison is made with specimens of equal size, and the important fact of the exceptional lightness of these woods is nowhere brought to our notice by these tests.

Spruce, 4, 4, 4, 4, is less stiff than white pine, even, but possesses greater strength and resilience, its moment of resistance reaching 18 foot-pounds, and twisting through a total angle of torsion of 200°.

Ash, 5, 5, 5, 5, seems to be weaker and less tough than is generally supposed; it is possible that the specimens tested were over seasoned. Its most striking peculiarity is its very rapid loss of strength after passing its limit of elasticity.

Black walnut, 6, 6, 6, 6, of the excellent quality and good condition, as regards seasoning, of the samples tried, is very stiff, strong and resilient, and is but little inferior to oak. Its resisting moment reaches 35 foot-pounds, and one specimen reaches a total angle of torsion of 220°.

Red cedar, 7, 7, 7, 7, is stiff, but brittle, and loses all power of resistance after twisting through an angle of 92°. A torsional moment of 20 foot-pounds only produces a total angle of torsion of 5°.

Spanish mahogany, 8, 8, 8, 8, is very stiff and strong. It is de-

ficient in toughness and resilience, losing its power of resistance very rapidly after passing the limit of elasticity.

White oak, 9, 9, 9, 9, has less torsional strength than either good mahogany, locust or hickory, but is remarkable for its wonderful toughness. It passes its limit of elasticity at 15°, but loses its resisting power very slowly indeed. We find the latter almost unimpaired until it has been subjected to a torsion of 70°; it only yielded completely at 253°.

Millwrights are evidently perfectly correct in holding this wood in high esteem for strength, toughness and power of resisting heavy shocks and strains.

Hickory, 10, 10, 10, 10, exhibits, in its curve, the remarkable pair of *maxima* already referred to, and has, apparently, the highest ultimate torsional strength, combined with unusual stiffness and considerable resilience. Its moment of resistance to torsion reaches a maximum of 58 foot-pounds.

Locust, 11, 11, 11, 11, has greater stiffness than any other wood in our list, and stands next to hickory in strength; it is, also, very resilient. Three diagrams are given, each of which possesses its own peculiarities. One specimen is only twisted through a total angle of torsion of 4° by a torsional moment of 48 foot-pounds.

Where more than one curve is given for the same wood, it is a fact worth noticing that the stiffness and ultimate strength are usually very nearly equal, and that the difference between the several specimens becomes marked, if at all, in their degrees of toughness.

In the formula for torsional strength, $Pa = Cd^3$, the curves give, values of C, as follows:

1. White Pine,	25	7. Red Cedar,	32
2. Yellow " sap,	35	8. Spanish Mahogany,	65
3. " " heart,	40	9. Oak,	53
4. Spruce	30	10. Hickory,	85
5. Ash,	43	11. Locust,	80
6. Black Walnut,	55	12. Chestnut,	35

Determining relative stiffness by obtaining values of the ratio of twisting moment to the total angle of torsion we obtain the following:

1. White Pine,	1·00	7. Red Cedar,	4·00
2. Yellow " sap,	2·25	8. Spanish Mahogany,	3·00
3. " " heart,	2·25	9. Oak,	2·53
4. Spruce,	0·67	10. Hickory,	4·15
5. Ash,	1.87	11. Locust,	5·50
6. Black Walnut,	2·63	12. Chestnut,	1·60

Taking the well established value for oak as a standard, we deduce the following values for the coëfficient to be used in the formula,

$$\theta = \frac{2\,Pa}{G\pi r^4} = \frac{\text{Total Angle of Torsion.}}{\text{Length of Part Twisted.}}$$

1. White Pine, . .	220,000	7. Red Cedar, . .	890,000
2. Yellow " sap, .	495,000	8. Spanish Mahogany,	660,000
3. " " heart, .	495,000	9. Oak, . . .	570,000
4. Spruce, . .	211,000	10. Hickory, . .	910,000
5. Ash, . . .	410,000	11. Locust, . .	1,225,000
6. Black Walnut, .	582,000	12. Chestnut, . .	355,000

Finally, by measuring the areas of the several curves, we deduce the following values for relative resilience, white pine being taken as the standard:

The work done in twisting off these specimens is found to have relative values as follows:

1. White Pine, . .	1·00	7. Red Cedar, . . .	1·61
2. Yellow " sap, .	3·01	8. Spanish Mahogany,	2·25; 1·65
3. " " heart,	3·87	9. Oak, ...	6·60
4. Spruce, . .	1·50	10. Hickory, . . .	6·90
5. Ash, . . .	2·25	11. Locust, .	7·65; 5·85; 320
6. Black Walnut,	5·00; 3·95	12. Chestnut, . . .	2·40

The values of coëfficients, as given, will be checked by additional experiments upon test pieces of the form shown in figure 4, carefully turned to a diameter of $\frac{3}{4}$ inch, and of a length, in the neck, of one inch.

Coëfficients for metals will also be given in a later communication.

Stevens Institute of Technology, Hoboken, N. J., Feb., 1873.

A French Inventor proposes to photograph dispatches to microscopic fineness, and blow them through a tube sunk in the Straits of Dover. When at their destination the dispatches could be enlarged again. By this method long dispatches could be sent about as cheaply and expeditiously as short ones.

Chemistry, Physics, Technology, etc.

REPORT OF THE COMMITTEE OF THE FRANKLIN INSTITUTE ON THE CAUSES OF CONFLAGRATIONS AND THE METHODS OF THEIR PREVENTION.

The undersigned, a special committee appointed by the Franklin Institute to ascertain the causes and the best means of preventing conflagrations, have given the subject careful consideration.

During the past year there were, within the limits of Philadelphia, 603 fires, an alarming increase over the year 1871, of over 41¼ per cent. Total loss by fire, $2,173,148.

Fifty-nine fires—the largest number originating from any one source—were caused by the explosion of coal oil and fluid lamps. The number of persons injured by these explosions and fires so as to cause death was about 100. 54 fires originated from downright carelessness, mostly with matches, gas and lamps; 51 by defective stove pipes, broken stoves, burning coal and wood falling upon the floor. 35 buildings were intentionally set on fire. 32 conflagrations were from spontaneous combustion; 24 originated from *tobacco-pipes* and *cigars;* 23 were caused by defective flues and 20 by fire works.

The use of petroleum in its various forms has been the most prolific cause of conflagrations. Hence the first section of our report this evening is on illuminating oils.

The best way of producing artificial light and heat is pre-eminently worthy the careful and profound consideration of the Institute. For these aids are the very source of all the mechanic arts. Without them society would revert to the level of the brute creation and the spontaneous productions of the earth. Hence, this subject has a legitimate paramount claim, for it is the very basis of the great cause of civilization. The use of petroleum is yet in its infancy. It is only thirteen years since its general introduction. Like gunpowder and steam, it has become indispensable. Like these, also, in the hands of knowledge, it is a faithful servant. In the hands of ignorance it is a dreadful master. Even in this city, proverbial for the intelligence of the great majority of the people, and where gas is so generally used, this illuminant has been the most fruitful cause of disastrous fires, and sudden, fearful, untimely death. In other cities, and

in the rural districts throughout the entire Union, the destruction of property and the death rate, in proportion to population, has been still greater. Ignorance and carelessness in the use of illuminating petroleum oils are the cause of the terrific conflagrations that, within scarcely more than the third of a generation, have probably destroyed more property and lives than were lost during the entire war of American independence.

The coal oil first introduced in the United States had a burning point of 124 degrees, and was used with great timidity and care. About 50 per cent. of the petroleum obtained from the wells, the light volatile product known as benzine, gasoline, &c., was thrown away, on account of the great danger of keeping it. The first demand for the light product was for chemical purposes and exportation; the price established for it at the wells was only two cents per gallon. Since that time it has gradually advanced, but has always remained much cheaper than the standard oil with its burning point of 110 degrees. Mixing any of the lighter forms of petroleum with oil that stands the Government test will greatly facilitate the lighting of old gummy wicks, and always increase the brilliancy and beauty of the light. Hence the retailer who uses the comparatively safe oil with a burning point of 110 degrees will be accused of keeping a poor article, and have his customers leave to buy of his neighbor, who, by adding benzine at about half cost, can sell a lower-priced oil, make more profit, and gain the reputation of keeping the best article the market affords. According to the present State law, no Government Inspector has the right to inspect or in any way prohibit the sale of any mixture of combination oils or combination burning fluids. The law expressly confines the State Inspector to coal oil and kerosene. The courts have decided that he has no jurisdiction over the sale of oils or fluids bearing any other name.

Hence, if the State Inspector should visit a retail store, and the proprietor has any doubt about the quality of his oil, he may claim that it is combination fluid, and if it should burn or explode even below the freezing point, the retailer is not only entirely exempt from the penalties of the law, but actually receives the plaudits of his customers for keeping an article so easy to light, so free to burn, and when actually on fire without confinement so readily to be extinguished. If the agents who traverse the country and set fire to volatile petroleum in a full, open lamp, were to permit it to be only partially filled with the fluid and remain long enough in a warm room to have the vacant

space in the lamp filled with the vapor or gas that is constantly emitted from the light petroleum or combination fluid at a high temperature, then an explosion would occur, the energy of which would be proportional to the amount of the mixture of the gas and atmospheric air. The State Inspector during the past year examined forty thousand barrels of coal oil and kerosene at wholesale stores, and there, through the defect of Legislative enactment, his labors ended. The rule will generally hold true that the more volatile the oil, the cheaper the fluid, the more dangerous the compound, the clearer and better the light. Hence the highly inflammable mixtures which yield most profit to the retailers and the most satisfaction to their customers are entirely beyond the scope of legal inspection. One of your Committee visited the dwelling at Morton station, where four persons were burned to death by the explosion of a can containing nearly a gallon of volatile petroleum or combination fluid. The room in which the explosion took place had a low ceiling, and a very large stove, which had been kept at nearly a red heat, in order to expedite a large ironing. There was no light or fire in the room except the one in the stove. A young lady was still conscious and lived long enough to describe her mother, who took the can of oil, removed the cork of the spout at the table, several feet from the stove. She instantly saw, on the removal of the cork, a flash go from the stove to the can, heard a loud, hissing noise, and that was all she remembered. A lady near the dwelling heard the explosion, and instantly saw the kitchen full of red flame. A gentleman near by ran to the rescue. About two minutes after the explosion the door was opened and the fire appeared to be extinguished. The can had been filled the day previous with a gallon of light petroleum, called combination fluid. Evaporation had been going on all day in the hot kitchen, from several lamps and the can. The room was evidently partly filled with the vapor of the fluid from the lamps, and the can, on the removal of the cork, a stream of vapor must have rushed from the spout to the strong draft at the stove, and, igniting, formed the stream of fire described previous to the instant explosion. The probable additional latent gas in the room also ignited and formed an intense heat that burnt the paper and paint of the room to a crisp in about two minutes' time.

We find by actual experiments that all the light forms of petroleum constantly generate vapor or gas even at the low temperature of 12 degrees above zero. This vapor, when properly controlled and managed, gives a clear white light, equal in brilliancy and beauty to the

best gas furnished by the city. But it appears impossible, in the present state of science, to use it with safety. No lamp can be made sufficiently secure to prevent the excessively volatile fluid from escaping from the lamp when it is not burning and the atmospheric air from filling part of the vacant space in the lamp after a part of the vapor has escaped or a part of the fluid has been burned. When the mixture goes on so that there is one part of gas and four parts of atmospheric air inside the lamp, or when these proportions exist in a room or any other apartment, they form a fearfully explosive mixture.

The number of deaths in the United States from the explosions of coal oil and fluid lamps for the year 1871 was, by the account kept by an insurance paper (the *Chronicle*), 3,500. If the death rate for 1872 kept pace with the increase of conflagrations, which was about 50 per cent., it would give for the past year 5,250 deaths, and the maiming of probably 20,000 persons within the jurisdiction of the United States. It is the peculiar characteristic of the explosive and exceedingly dangerous mixture of petroleum gas and atmospheric air to settle on the floor and remain there unperceived by either the sense of sight or smell. If there be no ventilation, and the supply of oil is abundant, the accumulation will go on till the apartment is filled from the floor to the ceiling. But the reverse is true with carburetted hydrogen gas furnished by the city, which will begin to fill at the ceiling and go down towards the floor; hence proper ventilation at the bottom and the top of every apartment where illuminating oils and gas are used tends to prevent explosions and conflagrations. It is always exceedingly dangerous to go into a close cellar or storeroom with a light or fire where vaporizing oils, burning fluids of any kind, or volatile spirits are kept. No family can retire at night with any degree of safety leaving cans of any of the light kinds of illuminating oils or burning fluids near a hot stove.

Any oil or burning fluid that evaporates rapidly or generates gas below one hundred degrees is exceedingly unsafe. It is easy for any one to determine the safety of any illuminating oil or fluid. First way: Take a small four-inch test tube, which can be obtained at a drug store for about five cents; fill it with the oil. If the evaporation in twenty-four hours exceed the fourth of an inch it is not safe. The best oil will remain for days without any perceptible diminution. If a test tube cannot be readily obtained, fill the fourth of a small teaspoon, pass a lighted match, or lighted taper, close to the oil or fluid to be tested, if it ignites at a surrounding temperature of less than one hun-

dred degrees it is totally unsafe to use about a dwelling. It is not the oil or fluid that explodes, but the vapor mixed with air. The act of carrying a lamp shakes the oil and facilitates evaporation. Also, the warmer the fluid the greater the amount of vapor evolved. Wicks of lamps after long use become conductors of heat. A burning wick turned down becomes a live coal, saves oil, and gives but little light, but always heats the metallic tube and collar, raises the temperature of the oil, increases its evaporation and consequent danger of *instant explosion*. Volatile oil and burning combination fluids generate vapor inside the lamp, hence the less the oil the greater the vacant space filled with vapor and atmospheric air, and the greater the danger, and hence it is apparent that to fill a lamp nearly empty while burning is almost certain to result in a terrific explosion. Extinguishing a lamp by blowing down its chimney increases the chance of explosion by igniting the gas inside. Light volatile oils are more dangerous to handle, where there is either light or fire, than gunpowder. The latter will only explode when fire is actually applied to it, but the vapor emanating from the former will, unseen, flow along a draft for many feet, and when least expected, as was the case at Morton station, form a train for instant overwhelming explosion and terrible loss of life. The present alarming condition of illuminating oils has been brought about by competition in business, and the general desire of the people to buy cheap. The fertility of resource, in the endeavor to utilize the lighter forms of petroleum, has added millions of dollars to the annual productive wealth of Philadelphia. Inventive power—the ennobling characteristic of free institutions—has caused petroleum to become the general illuminator, and Pennsylvania the oil emporium of the entire world. It has grown to be one of the largest items of commercial exchange between the United States and foreign nations—even India, China and Japan take petroleum for their products instead of gold. Safety to life and property are always of paramount importance. The quality of any oil or fluid is easily determined. Let the purchaser use the test-tube, or see if the oil in a small teaspoon can be lit with a match; if so, shun it as you would nitro-glycerine.

We recommend every one to try these safe, reliable tests before using any kind of petroleum illuminants, for, independent of the excruciating torture, long suffering and death that might befall the inmates of his own family, the conflagration may, by his neglect, at any time be wide-spread, as was the case at Chicago on the terrible

night of October 9, 1871. The labors of a life time may, by the explosion of a single lamp, be suddenly swept away by the irresistible besom of destruction. *Insurance companies, with millions of capital, may become bankrupt and lose their power as the faithful guardians of industry, the safe protectors of the unfortunate, the reliable endorsers of sacred legacies left to dependent widows and orphans—to institutions of learning and piety.* Hardly ever does a disastrous fire occur but many, by over-exertion and exposure, contract diseases that cause them, in the vigor and prime of life, to fill untimely graves.

The very best article the market affords ought to be bought by the poor as well as the rich, even if it costs 64 cents a gallon instead of 32 cents. The price will, even with the advance, be exceedingly low compared with former years before the introduction of the transcendently great and cheap illuminator which the world cannot now dispense with. By observing this golden rule the terrific disasters and conflagrations that have resulted from the use of the light, cheap forms of petroleum will hereafter be averted in this country, as they always have been, by observing stringent laws, in Continental Europe. Petroleum, properly managed, is a safe illuminant. The great cause of civilization cannot do without it. Inventive power may yet, by prudent management, render it the readiest, the safest and most desirable fuel in producing artificial heat for the mechanic arts and all the varied wants of man. The just value of the product of the oil wells of Pennsylvania for the year 1872 is upwards of fifty millions of dollars, or more than one-fourth the wealth of the entire agricultural productions of the State.

For full particulars we refer to the exhaustive report of the Secretary of the Institute, the ablest paper on the analysis and use of illuminants we have ever read.

In behalf of the committee,

J. B. Burleigh, Chairman.

The Light Petroleum Oils; Considered as to their Safety or Danger, in various Domestic Uses.

(*A Report to the Committee of the Franklin Institute, to inquire into the Causes of Conflagrations and the most efficient Methods for their Prevention.*)

Gentlemen:—In the field of illumination for public and domestic purposes, the direction of invention has been for sometime confined, not so much to the problem of creating new systems, as to the improvement of those already extant. Indeed, to one who fully appreciates the comprehensive advantages which coal-gas possesses for illuminating purposes, both æsthetically and sanitarily considered, and the elaborate conveniences which have been devised and so universally introduced, to render the details of its distribution and consumption perfectly automatic, while at the same time perfectly under control, the difficulties to be overcome by an innovator upon a field so thoroughly cultivated, will be comprehended.

Financial considerations, however, preclude the establishment of gas-works in locations other than large cities and towns—and for the benefit of those who are deprived of the luxury of coal-gas, inventors have most zealously striven. The development of the petroleum industry afforded a most effective spur to inventive genius, and has called forth a multitude of plans and processes for accomplishing this very necessary object. Of some of these it is the object of the writer, in the course of this report, to discuss the merits, as well as their bearing upon the score of safety. The composition and character of the petroleum oils are noteworthy, and the writer may hope to be pardoned for dwelling perhaps at too great length upon this point, since, otherwise, those who may not be conversant with the subject, will fail to comprehend the accuracy of any inferences which may be based upon them.

They are all of them composed of the elements carbon and hydrogen, and range, by imperceptible steps, from oils which are exceedingly light and inflammable to those which are heavy, thick, and viscous, and which can only be ignited at an elevated temperature. Nor is the material obtained from a certain locality to be regarded as a simple oil, since it is invariably a mixture of readily and difficultly inflammable oils. There is, of course, much difference in the appearance of the materials obtained from different locations—a fact most palpably manifested in their difference in gravity—but their general character is the same, whether found upon the shores of the Caspian

sea or in Pennsylvania. So numerous are the constituents of these oils, so closely do they resemble each other in their physical and chemical properties, that their separation and identification has afforded a problem which the skill of the chemist has thus far been baffled to solve; and the sum of our knowledge of them may be contained in the statement, that they consist of mechanical mixture of a great number of miscible hydro-carbons, whose gravities and boiling points increase by such imperceptible gradations that it is impossible to separate them, except roughly. For convenience sake, a number of commercial distinctions have been made, to which there is, at the present time, no valid reason to object. Of these, those which are known familiarly under the names burning oil or kerosene, benzine, and gasolene, alone concern the purpose of this paper.

Petroleum, according to Mr. S. Dana Hayes, State Chemist of Massachusetts, yields, by distillation, nine distinct products, as follows:—

Name.	Sp. grav. (Water, 1).	Sp. grav. Baumé.	Boiling point.
Rhigolene,	·625	—	65° Fahr.
Gasolene,	·665	85	120° "
C. Naptha,	·706	70	180° "
B. Naptha,	·724	67	220° "
A. Naptha,	·742	65	300° "
Kerosene Oil,	·804	45	350° "
Mineral Sperm Oil,	·847	36	425° "
Neutral Lubricating Oil,	·883	29	575° "
Paraffine,	·848 (?)	—	——

It must, however, be remarked, that the above figures express only the properties of the several products when obtained in as homogeneous a condition as it is possible to manufacture them commercially; and though under such circumstances the specific gravity of the oil affords a fair exponent of its inflammability, there can be no greater error than to trust to this as an infallible indicator of the quality of oils sold for household purposes.

Since this assertion may require explanation, it may be well to state that, owing to the perfect miscibility of all the petroleum products, it is possible, by simply mixing a light and a heavy product, to obtain an oil having a specific gravity ranging anywhere between the gravity of the two extremes of which it is composed. The temperature, however, at which such a mixture would evolve an inflammable

vapor, and that at which it would ignite, would be very materially affected; for such a mixture would not serve to neutralize the volatile qualities of the lighter oil.

An oil tested with the hydrometer might, for example, show a gravity of 45°13, but, instead of being a comparatively homogeneous oil, might be composed of a mixture of oils lighter and heavier, of which the indicated gravity simply showed the mean value. What is more important, however, such a mixture, instead of requiring a somewhat elevated temperature (about 120° F.), to evolve an inflammable vapor, as would be the case with a nearly homogeneous oil of this gravity, might ignite at all ordinary temperatures.

In regard to the inflammability of the petroleum products, two indications have been fixed, by which this quality may be conveniently estimated, and which at the same time afford the *only sure* indication of the safe or dangerous character of any of these products. These standards are called respectively the flashing and burning point. The first is the temperature at which the sample evolves an inflammable vapor; the second is that at which the oil itself ignites.

It will be evident, from what has been said, that we have here an infallible means of determining that which the hydrometer fails to indicate; namely, whether a sample of oil is a mixture, or is comparatively homogeneous.

Subjected to the first test, the lighter portions of the oil will successively rise to the surface, will be there converted into vapor, which, when evolved in appreciable quantity, will ignite with a succession of flashes on the approach of a lighted body.

If the sample is mainly composed of a heavy oil (whose boiling point is therefore high), this succession of flashes will be the only phenomenon at first observed; for the heat evolved from the momentary ignition of the lighter vapors given off, will not be sufficient to start the ignition of the whole body of oil. The temperature at which this phenomenon is first observed, is called the flashing point.

If the heating of the sample is continued, a temperature will soon be reached at which the remaining heavy constituent begins to evolve its vapors, which, when sufficiently rapid, will, upon being ignited, inflame the body of the oil itself. This temperature is called the burning point. By this test alone is it possible to determine the character of these miscible oils; and so certain are the indications which it affords, that in the several legal enactments with which it has been found necessary to surround the traffic in these oils, it has been relied upon to correctly indicate their quality.

In the preceding illustration, it appeared that the addition of a small quantity of light oil to a heavy one acted in such a way as to noticeably lower its flashing point. This action grows more marked as the amount of the adulteration increases, and will, when a very moderate dilution has been reached, also seriously affect the burning point of the mixture, the lighter portion of the sample being readily inflamed from the flash of the greatly increased volume of vapor which it throws off.

Dr. D. B. White, President of the Board of Health of New Orleans, found, for example, in experimenting with an oil which flashed at 113° Fahr., that an addition of

One per cent.	of	naphtha	caused	it	to flash at	103° Fahr.
Two	"	"	"	"	92°	"
Five	"	"	"	"	85°	"
Ten	"	"	"	"	59°	"
Twenty	"	"	"	"	40°	"

After the addition of twenty per cent., the oil burned at 50°.

It must be noticed that, though in general character the petroleum compounds are almost identical, yet, when considered in relation to their adaptability as illuminants, a marked distinction can be made.

The heavy oil boils at an elevated temperature, and at the ordinary temperature throws off only an inappreciable quantity of vapor. A lighted match, approached to an open vessel containing it, will not ignite it, and if plunged into the oil, it will be extinguished. With the other members of the series, however, the boiling-point is but a trifle removed from the ordinary temperature; and at the ordinary warmth of our dwellings, they are constantly throwing off volumes of vapor (the gasoline, of course, to a much greater extent than the naptha). A lighted match approached to an open vessel of either of them, will ignite them at once, and at some distance from the surface of the material.

It appears, therefore, that the light oils, owing to their extreme volatility, cannot be handled with the same indifference as the heavy ones. An open vessel, containing either of them, placed at some distance from the neighborhood of a flame, may, more likely than not, be the cause of sad mischief, and from a very simple cause. The vapor which it is constantly and imperceptibly giving off, flows from it in all directions, seeking the floor, in virtue of its superior density to the air—and once in contact with the flame—a flash—and the ignition arts, in an instant, back to its source.

Of the invidious, imperceptible nature of the dangers attendant upon their employment as illuminants, the public cannot be too clearly conscious, or too forcibly warned. And under no circumstances is the employment of these incendiary materials so severely to be condemned, as in the portable lamp so generally employed in the household. There are, it is true, circumstances under which they may be, with certain precautions, employed for other purposes than as lighting agents—and of these the writer will have occasion to speak further on—but, in the portable lamp, they may at any moment add another to the list of terrible accidents with which the public is already too familiar. Let the attention be but for a moment directed to the state of things involved. The body of the lamp is invariably of glass, and hence fragile. It is supposed to contain some of one of the lighter oils, the peculiar properties of which have just been alluded to. In the process of burning, the metallic attachments of the lamp will communicate sufficient heat to the body of the oil within, to fill the whole of the space above the oil with its vapor. So long, now, as the lamp remains unbroken, and its attachments without leakage, this circumstance is of little consequence, as, of itself, the confined vapor cannot be made to explode or ignite. But suppose the lamp, in this condition of things, to be shattered by a fall—a circumstance by no means infrequent—the consequence will inevitably be that the inflammable vapor in the neighborhood of the flame would at once ignite, and with it the whole body of oil in the lamp, to the imminent peril of person and property. Or suppose the equally probable circumstance, that the lamp, as before, should be refilled while burning, when the result might be, if possible, more disastrous than in the preceding case; for the volatile and inflammable vapors filling the upper portion of the lamp would inevitably, by their rapid diffusion into the air immediately surrounding the flame, form an explosive mixture, from the effect of which the lamp and its burning contents would be scattered in all directions. Where the oil made use of is one of proper quality, neither of the accidents here hypothetically stated would be possible, since, in no case, with a properly constructed lamp, could there be generated within the body of the lamp an amount of vapor sufficient to cause an explosion; nor could the oil itself be ignited at so moderate a temperature.

It is simply to be set down to good fortune, if one who has employed these oils for household purposes has escaped scot free, since no amount of care can avail against the inevitable result which must

follow one accident. It is easy to understand how persons ignorant of the highly dangerous character of the light petroleums may unknowingly make use of them in the manner above named; but it is really a matter of concern and surprise that so many, even of those who are thoroughly aware of the nature of the incendiary they are introducing into their households, are, nevertheless, thoughtless or indifferent enough to continue the suicidal practice—for no term can be too strong to properly characterize the fearful nature of the risk one is constantly running while employing these oils in the household.

There is, unfortunately, such a thing as too much legislation, as most communities are unfortunately aware, but there would seem to be no grounds for such a complaint on a subject which so intimately concerns the safety of the individual and the general public, as just this one. There are, it is true, laws which are intended to regulate the sale of this material, an inspection of its quality, and severe penalties, on paper, designed to punish those who sell, for illuminating purposes, an oil which will inflame below a temperature fixed by law at 110° Fahrenheit. But, most unfortunately, the legislation on the subject utterly fails to accomplish the end for which it was intended, namely, to protect the great body of the people, who are not supposed to be familiar with the nature of these materials, from the possibility of unknowingly running into such dangers as those which the writer has endeavored to make clear in what has preceded. And this lamentable state of affairs is due to the fact that the powers of the Inspector are limited to the examination of oils which are sold as refined petroleum, thus placing the host of dangerous patented compounds now flooding the market beyond his control—and from the fact also that the inspection is made *before* the oil leaves the hands of the wholesale dealer, and not after it has passed into the hands of the retailer, where it commonly is adulterated with a fair proportion of benzine. The temptation to this reckless practice is to be found in the fact that the benzine or naptha is considerably cheaper than the kerosene; and to this fact, as much as to the first named evasion, and insufficiency of the laws on this subject, is to be ascribed the host of misfortunes, which of late have multiplied with such alarming frequency as to horrify our public into serious consideration of the dangers they were unconsciously running.

An average crude oil contains—

	Per cent.	Price per gallon wholesale.	Price per gallon retail.
Cymogene, Rhigolene,	2	$1·50.	
Gasolene,	1·5	48 to 35 cents.	
Naphtha,	10	5 to 7 cents.	12 to 20 cents.
Benzine,	4	12 to 16 cents.	16 to 20 cents.
Kerosene,	55	20 to 25 cents.	30 to 40 cents.
Paraffin,	19·5	14 to 18 cents.	

Of these products, a very considerable proportion (about 15 per cent., as shown by the table) consists of the benzine or naphtha, and for this the demand in the various industrial arts is by no means equal to the supply; in consequence of which it commands but an inferior price in the market; in fact, considerably less than that demanded for the burning oils proper. Here, then, exists a direct temptation to dishonest or ignorant manufacturers and dealers to adulterate their stock of burning oil with oils of inferior price and dangerous quality. To what extent this reckless practice is carried on, the community have no just conception, but the writer feels safe in asserting that it is as general as any of the trade adulterations. The assertion is based upon the results of a large number of examinations into the character of oils from various portions of Philadelphia, sold to the public as burning oils; an examination which revealed the startling fact that, of a number of samples thus tested, only a trifling per centage of the whole number passed the ordeal of the fire test. In other words, the oils were, with the very few exceptions indicated above, simply burning oils, more or less liberally adulterated with benzine. How far these facts will go to explain the too often repeated instances of "coal oil horrors," the intelligent reader will be able to judge for himself. And it is certainly a melancholy species of consolation to know that what has been here shown to be true of Philadelphia, is true, also, of other large cities and towns. As an indication of the condition of things existing elsewhere, the writer would refer to the recently published annual reports of the fire inspectors of neighboring cities, in which attention is called, in most earnest terms, to the unusually large proportion of fires, accompanied, at times, with loss of life, during the year just passed, which were ascribable to petroleum; tracing them directly to an utter disregard for and inadequacy of the laws designed to protect the public against the danger of employing the light oils for household purposes.

From a recently published tabulation by the Fire Marshal of the city of Baltimore, it appears that out of 63 samples of oils, collected from various quarters of that city, but eight, or less than 13 per cent. of the whole number, were found to stand the fire test; and, as the laws regulating the traffic in these products have suffered no material modification since its publication, it is fair to conclude that this statement represents the average quality of the oils sold in that city to-day, if, indeed, an investigation should not show a yet lower percentage.

The writer regrets that it is not in his power to add to the above the results obtained by Prof. Chandler in his recent report to the Board of Health of the city of New York, a report replete with valuable information upon this subject, since that portion of the report relative to this item has not yet appeared in available form; but, from the tenor of the portion already made public, there can be no doubt that the results of his examination into the quality of the New York oils will strengthen that above quoted.

The following table gives the results of the examination made by the writer, in connection with Dr. T. R. Wolf, of Delaware College, of a number of samples of oils furnished by Dr. J. B. Burleigh, Chairman of your Committee, as having been obtained from various dealers, wholesale and retail, in this city and its neighborhood, and which may therefore be fairly considered to represent the average quality of the oils our citizens are using in their households:

No. of Sample.	Spec. Grav. Baumé.	Flashing Point. Fahr.	Burning Point. Fahr.
1	46°	84°	86°
2	46·5	74	86
3	65	54	54
4	66	51	51
5	64	55	55
6	48	117	120
7	64	54	54
8	45	74	86
9	64	54	54
10	70	51	51
11	46	89	100
12	48	64	75
13	46	93	100

No. of Sample.	Spec. Grav. Baumé.	Flashing Point. Fahr.	Burning Point. Fahr.
14	63	52	52
15	70	54	54
16	70	54	54
17	48	55	61
18	63·5	52	52
19	64	52	52
20	46	97	106
21	64	54	54
22	46	85	92
23	47	84	95
24	25	above 300	above 300
25	46	146	156
26	48	128	136

Most of these samples, notably Nos. 7, 9, 10 and 12, were obtained from firms who drive an extensive trade in retailing to small dealers; and establish the character of the material which is sold by the quart or pint at at least five thousand shops and stores throughout this city and its neighborhood. These prove to be amongst the most dangerous of any of the tested samples. That, however, which adds a peculiar interest to these specimens, is the fact that they are extensively advertised as safe oils, under specious names which disguise from the public their highly dangerous character.

Taking into consideration the extensive sale of the tested samples —as well as the fact that three of the four which were found to pass the government standard (Nos. 24, 25 and 26) were head light oils, which are rarely used in the household, but are mainly confined to railway use, lanterns, &c.—the proportion of safe oils really in common use by this public is so small as to be worthy of the gravest consideration. Including the oils just excepted, the proportion of safe oils used in our midst would be practically about one-twelfth of 1 per cent. An examination of the ten oil samples sold in the City of Wilmington, Del., by Dr. Wolf, shows a better result, the proportion of safe oils reaching as high as 12 per cent. It is probable, however, in view of the results published from other localities, that this showing is exceptionably favorable.

There seems to exist a notion that the explosive or inflammable properties of the light petroleums can be effectually neutralized by

adding various substances to them. The Patent Office records for the past few years contain numbers of claims for such mixtures of naphtha or gasolene with a great variety of substances, too numerous to mention.

Whether or not the inventors of these recipes really have faith in the claims they present is a matter of small importance; but the deceptive illustrations which they are able to offer in vindication of their assertions, no less than the attractive names which they attach to their incendiary mixtures, are the fruitful sources of many distressing calamities.

There is one simple and, for practical purposes, satisfactory method of determining the character of all such mixtures, and which applies equally as well to the common oils. Let a few drops be poured into a saucer, and apply a match; if the material burns, reject it as unsafe. The fact that the material can be set on fire at the ordinary temperature of our dwellings should be a sufficient evidence to a person of ordinary intelligence that, when employed in the household for heating or lighting purposes, it may, at the first thoughtless or careless act, become the cause of a frightful accident.

Hanging or stationary lamps of great variety of form and design have been constructed for burning these light compounds; gas and vapor stoves in similar variety have been introduced for household heating and cooking; but all of them should be shunned like the plague, and left severely alone.

In addition, another question of much practical importance presents itself, namely, What is the temperature to which the oil within the body of a lamp is heated while being consumed? From what has already been presented for your consideration it will require no explanation to assert that no oil is safe which can under such circumstances be heated above its flashing point.

For your inspection I append herewith several tables, containing the results of an extended examination of this branch of the subject, published with the recent report of Dr. Chandler, before alluded to.

For the sake of completeness, similar experiments, though not upon so extensive a scale, were conducted by the writer, which fully confirmed the results herewith quoted.

These results indicate that with lamps in common use the temperature of the oil within may even rise above the point fixed by law as the temperature of safety, and furnish excellent reason to urge, as does the author of the tables, that the laws upon this vital subject

should fix the flashing point of the oils used in the household at 120° Fahr., instead of at 100° Fahr., as is nominally the case at present.

THE TEMPERATURE OF OIL IN BURNING LAMPS.

FIRST SERIES.—*Temperature of the Room* 73 *to* 74° *F.*

No.	Kind of Lamp.	Capacity of Lamp.	TEMPERATURE OF THE OIL. After one hour.	After two hours.	After four hours.	After seven hours.	Average for the seven hours.
	Air of the room.....	.....	73°	73°	74°	74°	74°
1	Brass hand lamp	8 oz.	85	82	85	86	84·5
2	Brass hand lamp	24	79	83	84	82	82
3	Glass stand lamp	8	77	78	79	80	78·5
4	Glass stand lamp	11	77	81	84	82	81
5	Glass stand lamp	20	78	79	79	80	79
6	Glass stand lamp	7	82	80	85	84	82·75
7	Glass stand lamp	10	84	86	84	82	84
8	Glass hand lamp	9	79	78	85	85	81·75
9	Glass hand lamp	6	81	82	86	86	83·75
10	Glass hand lamp	7	80	78			79
11	Brass student lamp	13	82	80	83	84	82·25
12	Glass stand lamp	10	81	81	79	78	79·75
13	Brass stand lamp	11	92	89	88	86	88·75
14	Tin lantern	7	89	86	88	87	87·5
15	Glass bracket lamp	19	82	82	84	83	82·75
16	Glass stand lamp	29	82	80	80	84	81·5
17	Brass student lamp	7	80		88		84
18	Brass stand lamp	14	84	85	87	87	85·75
19	Brass stand lamp	12	100	100	92	91	95·75
20	Metal stand lamp	9	82	82	88	87	84·75
21	Brass stand lamp	12	91	92	88	85	89
22	Bronze stand lamp	16	83	76	79	85	80·75
23	Glass hand lamp		79	80	82	82	80·75

"With the air of the room at from 73 to 74° F., the temperature of the oil in the burning lamps ranged from 76 to 100° F., the highest temperature of 100° having been reached in a metal lamp at the end of one hour. That this was an exceptionally high temperature is shown by the fact that the highest temperature reached in any other lamps was 92° F. The following is a synopsis of the observations:"

	23 Lamps.	11 Metal Lamps.	12 Glass Lamps.
Highest temperature reached,	100°	100°	86°
Lowest " "	76	76	76
Average temperature,	83	86	81

SECOND SERIES.—*Temperature of the Room* 82 *to* 84° *F.*

No.	Kind of Lamp.	Capacity of Lamp.	TEMPERATURE OF THE OIL. After one hour.	After two hours.	After three hours.	After four hours.	Average for four hours.
	Air of the room..	.....	82°	83°	84°	83°	83°
1	Brass hand lamp	8 oz.	92	95	96	95	94·5
2	Brass hand lamp	24	88	94	94	93	92·25
3	Glass stand lamp	8	84	88	86	84	85·5
4	Glass stand lamp	11	84	86	86	84	85
5	Glass stand lamp	20	85	86	87	86	86
6	Glass stand lamp	7	86	87	88	88	87·25
7	Glass stand lamp	10	88	87	89	88	88
8	Glass hand lamp	9	87	90	90	90	89·25
9	Glass hand lamp	6	87	91	89	87	88·5
10	Glass hand lamp	7	84	86	86	84	85
11	Brass student lamp	13	86	88	88	88	87·5
12	Glass stand lamp	10	85	86	86	85	85·5
13	Brass stand lamp	11	104	103	101	101	102·25
14	Tin lantern	7	95	96	94	96	95·25
15	Glass bracket lamp	19	84	85	84	84	84·25
16	Brass stand lamp	29	84	85	84	84	84·25
17	Glass student lamp	7	87	88	86	84	86·25
18	Brass student lamp	14	91	93	92	91	91·75
19	Brass stand lamp	12	101	100	98	96	98·75
20	Metal stand lamp	9	89	92	94	93	92
21	Brass stand lamp	12	88	98	94	96	94
22	Bronze stand lamp	16	82	88	88	89	86·75
23	Glass hand lamp	6	84	86	85	84	84·75
24	Brass student lamp	10	120	120	120	118	119·5
25	Brass student lamp	12½	112	115	115	116	115

"With the air of the room at from 82 to 84° F., the temperature of the oil in the burning lamps ranged from 82 to 120° F. The temperature 120° was exceptional, being confined to one lamp. The following is a synopsis of the observations:"

	In 23 Metal Lamps.	In 12 Glass Lamps.	In 25 Lamps.
Highest temperature reached,	120°	91°	120
Lowest " "	82	84	82
Average " "	96½	86	91½

THIRD SERIES.—*Temperature of Room 90 to 92° F.*

No.	Kind of Lamp.	Capacity of Lamp.	TEMPERATURE OF THE OIL. After one hour.	After two hours.	After three hours.	After four hours.	Average for four hours.
	Air of the room.....	.....	92°	90°	92°	90°	91°
1	Brass hand lamp	8 oz.	90	98	100	98	96·5
2	Brass hand lamp	24	89	98	102	100	97·25
3	Glass stand lamp	8	88	90	93	94	91·25
4	Glass stand lamp	11	88	92	94	94	92
5	Glass stand lamp	20	85	92	94	94	91·25
6	Glass stand lamp	7	90	94	96	93	93·25
7	Glass stand lamp	10	90	96	96	96	94·5
8	Glass hand lamp	9	88	95	98	98	94·75
9	Glass hand lamp	6	89	95	96	97	94·25
10	Glass hand lamp	7	88	92	93	94	91·75
11	Brass student lamp	13	89	100	102	102	98·25
12	Glass stand lamp	10	88	92	93	93	91·5
13	Brass stand lamp	11	106	114	116	110	111·5
14	Tin lantern	7	99	106	107	105	104·25
15	Glass bracket lamp	19	85	92	91	91	89·75
16	Glass stand lamp	29	86	91	92	92	90·25
17	Brass student lamp	7	92	99	100	100	97·75
18	Brass student lamp	14	94	100	100	100	98·5
19	Brass stand lamp	12	108	112	112	107	109·75
20	Metal stand lamp	9	91	96	100	99	96·5
21	Brass stand lamp	12	104	110	108	106	107
22	Bronze stand lamp	16	84	90	95	98	91·75
23	Glass hand lamp	6	90	92	94	94	92·5
24	Brass student lamp	10	124	129	129	128	127·5
25	Brass student lamp	12½	120	126	127	127	125

"With the air of the room at from 90 to 92° F., the temperature of the oil in the burning lamps ranged from 84 to 129° F. The highest temperature being exceptional. The following is a synopsis of the observations:"

	In 25 Lamps.	In 13 Metal Lamps.	In 12 Glass Lamps.
Highest temperature observed,	129°	129°	98°
Lowest " "	84	84	85
Average " "	98¾	104½	92½

"By these results it appears that the temperature of oil in lamps often rises much above 100° F., thus reaching a temperature at which oil, *which does not emit a combustible vapor below* 100° *F.*, would be dangerous. It is apparent that 100° F. is too low a standard for safety; 120° F. would not be too high a standard, and its adoption would add but a few cents per gallon to the cost of the oil."

In view, therefore, of the facts here set forth, there would seem to be but one remedy available to the thinking portion of the community, namely, to urge the legislative bodies, with all the earnestness which the gravity of the existing condition of the subject demands, to make, with the least possible delay, such amendments to the laws regulating the sale and inspection of the petroleum oils, as shall render inspection a reality instead of a farce, which shall positively prohibit the sale or use of the dangerous petroleum products for household heating or illuminating purposes, and which shall punish with a severity commensurate with the gravity of the offence any violation of them, whether committed through ignorance or intention. The remedy here suggested could simply be reached by a judicious modification of the existing laws; and their vigorous enforcement would prove an effectual barrier against the sale of the adulterated stuff which now provides almost every household with a treacherous, insidious enemy.

Continuing the consideration of the modern innovations in the field of illumination, certain methods, by which the light oils of petroleum (gasoline especially) are made use of, to improve the illuminating power of ordinary burning gas, warrant attention. These processes are essentially the same in principle, though differing very greatly in the details of the devices in carrying out the idea; and when carried into effect, with certain obvious precautions, which will be referred to hereafter, are, to some extent, though by no means entirely, free from the vital objections on the score of danger, upon which so much stress has been laid in the preceding pages of this report. And the writer begs leave, once for all, to state his firm conviction, that it would prove a matter of inestimable benefit, if some method should be discovered and applied, either for converting these

volatile bodies into useful and harmless compounds, or if some process should be devised for utilizing them largely in the industrial arts. By either of these remedies the direct employment of the light oils for household illumination could be altogether avoided; since, though the ingenuity of invention may be exercised to devise preventives and precautions against accident with them, it is very gravely to be doubted, from the very nature of the materials, whether they can ever be so employed with a reasonable degree of safety.

The philosophy of the processes here referred to will be more clearly understood by a general reference to the principles involved in the utilization of illuminating agents. These are generally compounds of carbon and hydrogen, the so-called hydro-carbons, and are either already in the gaseous state, or are converted to this condition in the process of burning. A certain proportion of these elements is, however, necessary, in order that the illuminant shall burn with proper brilliancy. To the hydrogen of the burning body is to be mainly ascribed the heating power of its flame, while to the carbon alone are we indebted for its illuminating qualities. It is, therefore, possible that a hydro-carbon may possess too much hydrogen in proportion to its percentage of carbon (as is the case with the light carburetted hydrogen, for example), when the effect will be that of a hot flame, but almost or entirely blue, and with little or no light-giving power. Or, on the other hand, the burning body may contain an excessive proportion of carbon (as is the case, for example, with turpentine oil), when the result will be a dull red, dirty, smoking flame, which, though giving out more light than the first, is utterly objectionable on the score of the abomination of its smoke. It is, therefore, a matter of the first importance that, in an illuminant, these essential constituents shall be present in such proportions as shall produce the best illuminating effect.

With the common burning gas, the reason of its very general inferiority is to be referred to the large percentage of the light carburetted hydrogen gas and of free hydrogen itself, which it contains. The rationale of the introduction of these feeble or non-illuminating ingredients into the gas is not difficult to comprehend if a glance be taken at the operation of its manufacture.

In the process of obtaining burning-gas from fat coal, which is the one almost universally employed in gas-works, the rich, light-giving gas is evolved during the earlier portions of the heat; but, owing to the natural desire of the companies to secure from a charge the largest

quantity of gas, the heat is continued for a considerable time after the richer portions of the gas have passed off; the consequence of which is, that the gas passed over in the holder during this period is very largely composed of hydrogen, which has no illuminating power, and of the light carburetted hydrogen, which is not much better.

The fact that the gas supplied for household consumption is generally but of indifferent quality, mainly from the cause specified above, has originated a number of plans for improving its brilliancy, by supplying it indirectly with a portion of the constituent in which it is lacking, namely, carbon. This process involves the passage of the gas, before consumption, through a reservoir of some one of the light petroleum oils, preferably gasoline, on account of its eminent volatility; by which treatment it becomes charged to saturation with the vapor of this material, the illuminating power of which is very superior, and comes to the burner greatly improved in quality.

This process, which bears the name of "carburetting," has received, in several cities, a limited introduction. The volume of the gas is by this process considerably increased, as well as its illuminating power; and this, together with the cheapness of the carburetting material, the smaller quantity of gas which need be consumed to produce a given amount of light, as compared with that which would be required without its presence, combine to considerably diminish the expense of employing gas—an item, it must be granted, of no inconsiderable importance in large establishments where a large number of burners are regularly in operation. And it is in such establishments that this plan, or others, which will presently be alluded to, have been received with the most favor.

Where a limited number of burners are in requisition, as in smaller workshops, stores or private dwellings, the saving which may thus be effected in the item of expense, is scarcely a matter sufficiently important to offset the disagreeable routine of attention which it is necessary to devote to the apparatus to keep it in effective operation. Other incidental difficulties, such as the natural hesitation on the part of those familiar with the unavoidable risk entailed upon the handling of the carburetting material, and perhaps the still more cogent reason, that the insurance interests have, in most localities, prudently refused to sanction or permit the introduction of the process, in connection with risks assumed by them, have so combined to limit the application of the process of carburetting, that it is, though not new, still comparatively unknown to the general public.

Although the introduction of any of the lighter oils of petroleum into buildings for illuminating purposes will be discountenanced by all who seriously and candidly reflect upon the unavoidable risks which attend their employment, it must still be granted that, if these substances are to be employed at all, this and allied plans, in which the inflammable material is securely confined in a metallic reservoir, is infinitely to be preferred to the practice of using them in the lamps or stoves.

In connection with the modern processes for the utilization of the light petroleum oils, there remain yet to be reviewed a number of plans by which this is accomplished directly; although, through the intervention of appliances considerably more complex than the portable lamps. Reference is here made to the numerous devices which are popularly termed gas machines.

These consist, in general terms, of a reservoir, generally a strong metallic vessel, supplied with the oil to be utilized, through or over which a regulated supply of air (or in some cases of hydrogen) is passed, the illuminating agent resulting from this contact being then led, by the usual distribution-pipes, to the burners. In the simplest form of apparatus operating upon this principle, this result is accomplished by permitting the gasoline vapor, which is considerably heavier than the air, to fall, in virtue of its gravity, down a descending pipe, and thus, by the current established, induce a flow of air over the surface of the oil. The material is suitably contained within a reservoir provided with an opening at one extremity, to permit of the access of the air, and further, with a series of alternating, imperfect partitions. The object of the latter is to increase the amount of contact between the entering air and oil, and to effect what would be equivalent to a large evaporating surface. The more rapidly the gas is consumed from the burners, the more rapid will be the evaporating process, which will, of course, cease as soon as the burners are turned off. Thus, by ingeniously taking advantage of the extreme volatility of the light oil, an air-current is induced, by which an abundant supply of excellent illuminating gas is obtained automatically, without the introduction of any appliance other than the reservoir with its simple partitions. This plan, though very interesting, from its simplicity and the scientific principle which it so ingeniously illustrates, involves the serious necessity of placing the reservoir of oil in the upper story of the building to be lighted. It contains the essential features, though the object is attained in the simplest possible manner, of all the numerous gas-machines. In the others, a fan or its equivalent is employed to

blow into the reservoir a stream of air. Though somewhat more complex in construction, this form of the apparatus is less objectionable than that first described, from the fact that the reservoir of oil may be located at a considerable distance from the house, and beneath the ground, in a pit prepared for the purpose—thus lessening the risk by lessening its proximity to the building endangered by its presence; though, with all of them, the personal dangers attending the replenishing of the reservoir, remain the same, as does also the liability to explosion, when a leakage occurs or from an accidental deficiency of oil in the reservoir, or extremely cold weather, a defect in the proper working of the apparatus, or from any other cause, an excess of air is introduced by the blower. Where such a condition of things occurs, an explosion is the inevitable consequence, since the instant the proper mixture of air and vapor is reached, the combustion of the gas at the burners will dart instantly back to the reservoir with all the explosive violence of gunpowder.

With the hydrogen machine, where a current of hydrogen gas (generated, in an appropriate vessel, from the action of diluted sulphuric acid upon iron scrap), is passed through the reservoir of oil, though it seems not to be so liable to an accident from this source, and affords a light much superior to that obtainable with the other forms of machine, is more obviously objectionable, on the score of complexity of the operations involved in its working, not the least of which consists in the replenishing, from time to time, of the generating vessel; an operation which, from the character of the acid and its refuse, is a most disagreeable one. Another objection, however, which far more effectually extinguishes the possibility of this process ever gaining popularity, resides in the fact that the gas obtained by it costs, to say the least, three times as much per thousand feet as the ordinary burning gas. The sale of the refuse to the manufacturing chemist, for the extraction of the green vitriol, and the diminution in the quantity of gas consumed, by reason of its excellent illuminating quality, may effect a slight reduction in the grave item of expense, but this will, even under the most favorable circumstances, be too great to permit of any other than a very limited introduction.

With this somewhat lengthy consideration, the gas machines may be passed by; though, in conclusion of this branch of the subject, a few words upon their merits may not be thrown away.

They possess, one and all, the objectionable feature of employing the incendiary petroleum oils; and though they, as a class, reduce the danger of its presence to a minimum, by confining the material

in a strong metallic vessel, and by locating this at some distance from the buildings to be lighted, the danger from disarrangement or carelessness is but incompletely guarded against, as has already been pointed out, and the personal risk involved in the execution of the routine of attention, which they demand, remains unprovided for.

In the foregoing pages, the entire unfitness of the light petroleum oils has been urged, under whatever name, or with any form of lamp or machine, as household illuminating or heating agents, from the belief that under no circumstances can these substances be so employed without great risk: with the least objectionable modes of their application, namely, in the carburetter and the gas machine, the writer was, until lately, of the opinion that they might, with the exercise of well-defined precautions, be used with a reasonable degree of safety; but a thorough examination, with the knowledge gathered from a more extended acquaintance with the statistics of the subject, have prompted a revocation of that opinion and this expression of it.

There is no field, at present, in which invention would prove of such eminent service to the community at large, as in that of devising methods by which these oils would be utilized upon a vast scale, and thus effect their withdrawal from those applications in which their dangerous qualities are so prominently involved, to the constant peril of life and property. That this object will ultimately be accomplished there can be no doubt. Already, large quantities of these materials are exported, to be converted into permanent illuminating gas, by a process analogous to that employed in our gas-works, the retort and its setting being modified to suit the purpose. Their utilization in other departments of the industrial arts is gradually extending, and it is sincerely to be wished that the time may be not far distant when the demand for them in these legitimate fields of employment may be more than sufficient to meet the supply. As an indication that progress is being made in this direction, this report, which has grown into far more considerable proportions than was originally intended, may be appropriately concluded by a description of the most recent of all the plans for illumination, and in which the light petroleums are called upon to do good and proper service.

The plan consists of three distinct steps: First, the continuous production of hydrogen gas; second, the passage of the hydrogen through a well of the light oils; and third and most important, the conversion of the vapor-laden hydrogen into a permanent gas.

The first step in this ingenious invention consists in leading steam into a furnace charged with coke and heated to redness, by which pro-

cess hydrogen and carbonic oxide are formed. From this mixture the carbonic oxide is removed by passing the gases through cylinders of hydrated lime heated to redness. The result of this treatment is the formation of a fresh equivalent of hydrogen, and the conversion of the carbonic oxide into carbonic acid by union with the oxygen of the decomposed water of hydration. The carbonic acid is removed from the hydrogen by passing through more lime, and the hydrogen is passed onward into another chamber, where it comes into intimate contact with a body of light petroleum oil. Here it loads itself with the oil-vapor, and continues on its course, passing next through tubes heated to a low, red heat, whereby a permanent coal-gas is formed precisely analogous in all its properties to the ordinary coal-gas, though superior to the last (as ordinarily furnished the public) in illuminating quality.

A process which would secure to those living remote from cities, and who are necessarily deprived of the luxury of coal-gas, some substitute for the petroleum gas machine, which shall equal it in the quality of its illuminant, but at the same time shall be free from its objectionable features, would be a more direct means of effecting this much-to-be-desired result, though it affords a problem far more difficult of solution.

In the report herewith submitted to you, it has been my constant effort to present for your consideration, the facts at my disposal freed from any bias.

In the city of Baltimore, during the past year, 69 fires were caused by petroleum and its products. During the same period, in the city of New York, there were 203 from the same cause; while in your own city, no less than 59, or more than from any other single cause, are officially announced to have occurred.

Many of these disasters were accompanied with considerable pecuniary loss, and not a few with deplorable loss of life or injury of person; and I need hardly remind you that the memorable calamity at Chicago, which has become historical from its appalling magnitude, is popularly ascribed to a similar cause.

Suitable laws respecting the sale and employment of these substances, rigidly enforced, might have averted the greater number of these misfortunes.

It is for you, gentlemen of the committee, to present your convictions upon this subject so forcibly as to leave no ambiguity in the public mind as to your meaning; and thus, by the authority which any recommendation from you must carry with it, to pave the way for that stringent legislation upon this matter which is so urgently needed.

If the matter herewith presented for your consideration proves of any service in adding force to such an expression from you, I shall regard my labor as not having been altogether in vain.

Very respectfully, yours, WILLIAM H. WAHL.

To Messrs. J. B. Burleigh, Ch'n, Frederick Fraley, Henry Cartwright, Chas. S. Close, Dr. George A. Kœnig, Dr. T. R. Wolf, Committee.

Franklin Institute.

Proceedings of the Stated Meeting, January 15, 1873.

The meeting came to order at the usual hour, with the President, Mr. Coleman Sellers, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that, at the stated meeting held January 8th, 1873, the following donations to the Library had been received, viz.:

Transactions of the American Society of Civil Engineers for 1871–72. From the Society.

Account of the Operations of the Great Trigonometrical Survey of India, Vol. I. From the Director of the Survey.

Quarterly Weather Report of the Meteorological Office, London, from January to March, 1872. From the Meteorological Office.

Memoirs of the Historical Society of Pennsylvania, Vol. X; with a Catalogue of the Paintings and other Objects of Interest belonging to the Society. From the Society.

Proceedings of the Philosophical Society of Glasgow, Vol. VIII, for 1871–72. From the Society.

Twentieth Annual Report to the Council of the City of Manchester on the Working of the Free Public Libraries; with Catalogues of the Libraries. From the City of Manchester.

The President next presented his annual report for the year just passed, in which the operations of the various branches of the Institute were reviewed. The report dwelt particularly upon the continually improving prospects of the Journal, and the enlarged capacity and usefulness of the Drawing School. The reasons for the postponement of the expected Exhibition were reviewed by the President, and the adverse decision of the Committee having the project in charge was approved. The report was accepted.

The Actuary next reported the minutes of the several Standing Committees.